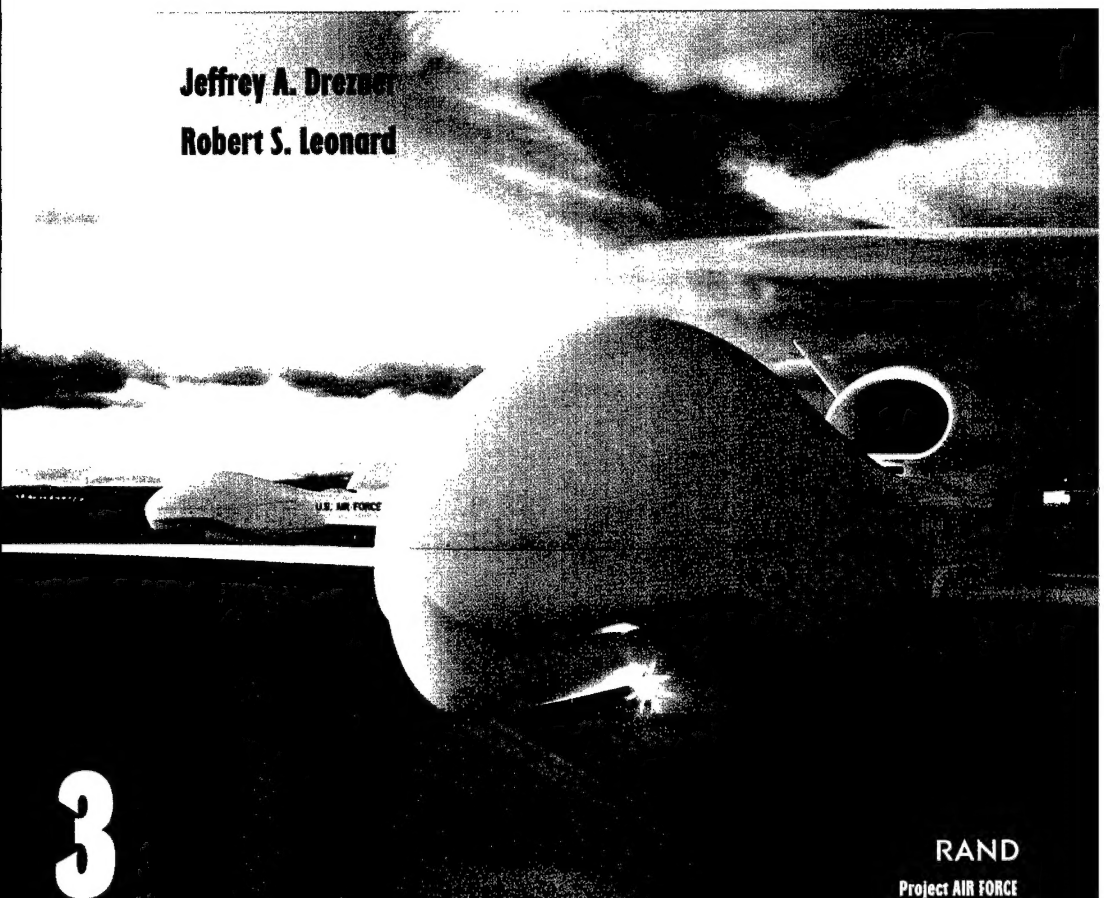
INNOVATIVE DEVELOPMENT

Global Hawk AND DarkStar

Transitions Within and Out of the HAE UAV ACTD Program

Jeffrey A. Drezner
Robert S. Leonard



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RAND
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Jeffrey A. Drezner
Robert S. Leonard

Prepared for the United States Air Force

RAND
Project AIR FORCE

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PREFACE

The transitioning of complex development programs from one agency to another—as well as from development and test to production—constitutes a major management challenge. This challenge takes on an added dimension when a program's acquisition strategy is highly innovative. The High-Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) Advanced Concept Technology Demonstration (ACTD) program incorporated a number of innovative elements into its management approach. As a condition of conducting this ACTD, Congress required that an independent third party study its implementation. RAND was chosen for this role and has been following the HAE UAV ACTD program since its inception.[1]

Initial research was sponsored by the Defense Advanced Research Projects Agency (DARPA); the current research was sponsored by the U.S. Air Force. The core objective of the research was twofold: to understand how the innovative acquisition strategy used in the HAE UAV ACTD program affected program execution and outcomes, and to draw lessons from this experience that would be applicable to the wider acquisition community.

The HAE UAV ACTD program transitioned from DARPA to Air Force management during the ACTD portion of the program. The Global

[1]See Geoffrey Sommer, Giles K. Smith, John L. Birkler, and James R. Chiesa, *The Global Hawk Unmanned Aerial Vehicle Acquisition Process: A Summary of Phase I Experience*, MR-809-DARPA, Santa Monica: RAND, 1997; and Jeffrey A. Drezner, Geoffrey Sommer, and Robert S. Leonard, *Innovative Management in the DARPA High Altitude Endurance Unmanned Aerial Vehicle Program: Phase II Experience*, MR-1054-DARPA, Santa Monica: RAND, 1999.

Hawk element of the HAE UAV program subsequently transitioned from an ACTD to a Major Defense Acquisition Program (MDAP). This report addresses these transitions and their associated management issues. Specifically, we assess which elements of the acquisition strategy facilitated the transitions and which aspects led to problems. This report is one of three supporting documents resulting from the current research effort; the other two documents address activity content and program outcome issues and analyze the flight test program. A separate executive summary draws broad lessons from the HAE UAV experience.

This research was sponsored by the Global Hawk System Program Office (GHSPO) in the Aeronautical Systems Center, Air Force Materiel Command (ASC/RAV). It was conducted within RAND's Project AIR FORCE.

Reports in this series are:

MR-1473-AF, *Innovative Development: Global Hawk and DarkStar—Their Advanced Concept Technology Demonstrator Program Experience, Executive Summary,* Jeffrey A. Drezner, Robert S. Leonard

MR-1474-AF, *Innovative Development: Global Hawk and DarkStar—HAE UAV ACTD Program Description and Comparative Analysis,* Robert S. Leonard, Jeffrey A. Drezner

MR-1475-AF, *Innovative Development: Global Hawk and DarkStar—Flight Test in the HAE UAV ACTD Program,* Jeffrey A. Drezner, Robert S. Leonard

MR-1476-AF, *Innovative Development: Global Hawk and DarkStar—Transitions Within and Out of the HAE UAV ACTD Program,* Jeffrey A. Drezner, Robert S. Leonard

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SUMMARY

The United States has seen a three-decade-long history of poor outcomes in unmanned aerial vehicle (UAV) development efforts. Technical problems have led to cost and schedule increases as well as to disappointing operational results. Costs have tended to escalate so much during development that the resulting systems have cost more than users have been willing to pay, precipitating program cancellation in almost every case. This history prompted the unique developmental approach adopted at the beginning of the High-Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) Advanced Concept Technology Demonstration (ACTD) program.

There has also been a long history of efforts made to improve the efficiency and effectiveness of weapon system acquisition policy, processes, and management for all weapon system types. Capturing the experience from ongoing or recently completed efforts employing nonstandard or innovative acquisition strategies can facilitate such improvements. This research contributes to that effort.

In 1994, the Defense Advanced Research Projects Agency (DARPA), in conjunction with the Defense Airborne Reconnaissance Office (DARO), began the development of two UAVs. These systems were intended to provide surveillance information to the warfighter. As such, they responded both to the recommendations of the Defense Science Board and to operational needs stated by DARO on behalf of military service users.[1]

[1]See also *Long Endurance Reconnaissance, Surveillance, and Target Acquisition (RSTA)* (JROCM-003-90, 1990), which documents a need to provide commanders in chief

The HAE UAV ACTD program consisted of two complementary system development efforts: the conventionally configured Tier II+ and the Tier III–, which incorporated low-observable (LO) technology into the design of the air vehicle. The program also included a common ground segment (CGS) that was intended to provide launch, recovery, and mission control for both air vehicles. The ACTD program was structured into three phases. Phase I was a design competition for the conventional Tier II+ system. Phase II included the development and test of both the Tier II+ (Global Hawk) and the LO Tier III– (DarkStar). Phase III involved the demonstration and evaluation (D&E) activity leading to a military utility assessment (MUA).

RAND has been analyzing the execution of the HAE UAV ACTD program's innovative acquisition strategy since the program's inception in 1994. The objective of this research was twofold: to understand how the innovative acquisition strategy used in the HAE UAV ACTD program affected the program's execution and outcomes, and to identify lessons that might be applied to a wider variety of programs in order to improve DoD acquisition strategies. Previous reports have documented the effects of that innovative acquisition strategy on Phase I and Phase II of the ACTD program.[2] The current research addresses the completion of Phase II, the transition to Phase III, and the transition to post-ACTD activities.

The HAE UAV ACTD program included two challenging management transitions. The first was the transition of management responsibility from DARPA to the Air Force within the ACTD program. The second was the transition from an ACTD to a Major Defense Acquisition Program (MDAP) under Air Force management. Both transitions affected and were affected by the program's unique and innovative acquisition strategy. The ability to accomplish these

(CINCs) with responsive, long-endurance near-real-time RSTA capability against defended areas; *Assured Receipt of Imagery for Tactical Forces* (JROCM-044-90, 1990), which documents a need for rapid, effective, and continuous dissemination of imagery; and *Broad Area Coverage Imaging* (JROCM-037-95, 1995), which documents a need for on-demand, near-real-time battlefield imagery.

[2]See Geoffrey Sommer, Giles K. Smith, John L. Birkler, and James R. Chiesa, *The Global Hawk Unmanned Aerial Vehicle Acquisition Process: A Summary of Phase I Experience*, MR-809-DARPA, Santa Monica: RAND, 1997; and Jeffrey A. Drezner, Geoffrey Sommer, and Robert S. Leonard, *Innovative Management in the DARPA High Altitude Endurance Unmanned Aerial Vehicle Program: Phase II Experience*, MR-1054-DARPA, Santa Monica: RAND, 1999.

transitions smoothly was critical to the program's success. This report explores these two challenging transitions within the context of the innovative acquisition strategy used in the program. The goal is to understand the impact of that strategy on transition management issues.

The HAE UAV ACTD program transitioned from DARPA to Air Force management on October 1, 1998, approximately one year later than planned. At the time, Global Hawk air vehicle 1 had completed five airworthiness/functional checkout sorties for a total of 20.5 flight hours; air vehicle 2 was still two months from its first flight. DarkStar had resumed flight testing with air vehicle 2 only five months earlier and had completed only three sorties accumulating 2.26 total flight hours. Phase III start was still nine months away (the first D&E flight was June 19, 1999), imposing an added delay on the slip in management transition; the program was supposed to have transitioned to Air Force management at the beginning of Phase III.[3] Post-ACTD planning had not yet been approved, although some small related efforts were under way in connection with the transition activities just completed. The Australian demonstration was still in the early planning and feasibility stages. When the program transitioned to the Air Force, the ACTD program was planned for completion in June 2000. The MUA was to be produced by the Joint Forces Command (JFCOM) at that time.

Two years later, in October 2000, the ACTD program was essentially complete, and a positive MUA report had been issued by JFCOM.[4] The program office was working toward a Milestone II/low-rate initial production (LRIP) decision scheduled for that month to approve entry into an initial one-year engineering and manufacturing development (EMD) program. Further work was to be based on spiral development, an approach consistent with evolutionary acquisition in which continuing nonrecurring engineering activities result in scheduled block upgrades. The October 2000 Defense Acquisition

[3]Interestingly, this desynchronization of management and phase transition had the effect of clouding the actual transition to Phase III activities. Phase III D&E planning took place throughout the year prior to the formal start of Phase III in June 1999.

[4]JFCOM is the renamed United States Atlantic Command (USACOM) with additional responsibilities in requirements development and experimentation. The final MUA was dated September 2000.

Board (DAB) II was delayed until December 2000 as a result of continued disagreement regarding the specifics on the evolutionary approach (i.e., on the requirements and capabilities associated with each block as well as on timing and quantities). The December 2000 DAB did not take place. The Milestone II decision finally came on March 6, 2001.

Over its 30 months of managing the ACTD program prior to Milestone II, the Air Force program office was occupied with three simultaneous primary management tasks: conducting the flight test program; planning for a transition from ACTD to the traditional acquisition process; and requirements generation and concept-of-operations (CONOPS) development, especially as it related to post-ACTD activities. In all these efforts, the innovative acquisition approach that characterized the program under DARPA management continued to have a significant effect on program management, events, and outcomes. In particular, the program's designation as an ACTD, its use of Section 845 Other Transaction Authority (OTA), and the lack of firm performance requirements had the greatest influence on the two management transitions.

Residual assets at the end of the ACTD included four Global Hawk air vehicles, two synthetic aperture radars (SARs), one integrated sensor suite (ISS) (acquired after the destruction of the first ISS), two mission control elements (MCEs), and three launch and recovery elements (LREs). Two additional air vehicles (air vehicles 6 and 7), built as part of the activities bridging the ACTD and MDAP programs, will be delivered in FY 2002; these will have a somewhat different configuration than previous air vehicles, requiring modifications to the ground segments.

Overall, the innovative acquisition strategy used in the HAE UAV ACTD program had a positive effect on program execution. Although the strategy can be improved, we believe that it was successful in accomplishing the program's main goals: demonstrating a new capability and operational concept at a lower cost and in a shorter time frame than would a traditional acquisition program. More significantly, the innovative approach used in the HAE UAV ACTD program allowed for the introduction of a new capability to the operational forces—an outcome that would have been highly unlikely under traditional approaches.

Although both transitions were ultimately successful, the transition from the ACTD construct to an MDAP using traditional processes was clearly the more challenging. Many of those challenges were a direct result of the acquisition strategy:

- The ACTD construct intentionally focused program activities on demonstrating the military utility of a new capability, technology, or operational concept while limiting activities related to operations and supportability. Supportability is a legitimate concern of the force provider (operational user), as is CONOPS. This critical difference in focus led to some problems in Global Hawk's transition to an MDAP, particularly with respect to the defining of operational requirements and block upgrades.
- The ACTD construct has a bias toward transitioning directly into low-rate production of the ACTD configuration.[5] While this may make sense for some systems (e.g., unique command-and-control systems or software development), it is not appropriate for a complex system such as Global Hawk. This raises the issue of how to transition into an MDAP-style development program that takes advantage of the technical maturation that has already occurred under an ACTD. A related issue concerns the timing of funding and program go-ahead decisions (i.e., military utility decisions); there is a conflict between the information available from the ACTD at any point in time and that required to program for and fund large, complex systems in the two-year Planning, Programming, and Budgeting System (PPBS) cycle.
- The use of OTA does not appear to have greatly affected either transition. The inherent flexibility of OTA helped program management deal with the uncertainty surrounding Global Hawk's transition to MDAP status. While both the program office and the contractor expended significant effort transitioning management processes from the contractor-dominated processes under OTA to more traditional processes under the Department of Defense (DoD) 5000 series policy, the costs of those efforts are unknown. We do know that the

[5]See "ACTD Guidelines, Transition," October 1999, available at www.acq.osd.mil/actd/guidelns/.

contractor and the Global Hawk System Program Office (GHSPO) spent considerable effort on those activities.

- Similarly, the use of Integrated Product and Process Development/Integrated Product Team (IPPD/IPT) processes eventually led to a strong collaborative working relationship between contractor and government, thus facilitating both transitions.
- Early user participation was a core purpose of the ACTD. Problems arose in the transition from ACTD to MDAP only because the change in status also involved a transition of users from JFCOM to the Air Combat Command (ACC). These users have very different perspectives, different definitions of military utility (affecting operational requirements and concepts), and different preferences with regard to system configurations and capabilities. Current ACTD and MDAP policy and practice do not have well-defined mechanisms for addressing the conflicts that may arise from these differing perspectives.
- The lack of firm performance requirements throughout the ACTD program resulted in some difficulty in defining operational requirements for the MDAP program. Yet the lack of specific performance requirements is a hallmark of ACTDs and is the reason such efforts can demonstrate new technology, capabilities, and operational concepts. While we acknowledge the difficulty the operational user had in defining and gaining approval of an operational requirement, we believe that modifying this aspect of the ACTD construct would result in a substantial loss of benefits.

RECOMMENDATIONS FOR FUTURE PROGRAMS

Cost and schedule were essentially fixed in the HAE UAV ACTD program, with performance having some degree of flexibility. We believe that cost, schedule, and performance should all be stated as goals to be traded off within identified bounds. This allows more intelligent trade-offs to be made, leading to more cost-effective solutions. When one or more of these parameters are fixed, the program becomes highly constrained and may not produce optimal trade-offs. Of course, this requires that the acquisition and user communi-

ties show flexibility in requirements and operational concepts, total development budgets, and program schedules.[6] Such flexibility would have facilitated the transition to MDAP status.

In future programs, all organizations with an interest in the program, both in the current phase and in later phases, should have significant input into early planning. Perhaps the dominant problem Global Hawk overcame lay in the fact that key elements of the Air Force—particularly the operational users (ACC)—did not buy into the program. Had these elements been involved up front, the effort might have seen a smoother program execution and transition into the force structure. Early management plans should make it clear that the designated lead agency for post-ACTD activities should fund the operationalization of the system and define a role for the operational user supporting the ACTD-designated commander in chief (CINC) user.

In future programs, operational users must also be incorporated into program decisions and processes at an earlier juncture, as it is these users who have both the resources and the knowledge to actively participate in the development process. Users must include both those who will operate the system and those who will integrate that system into overall warfighting efforts. In most cases, these are different communities or organizations with different perspectives, cultures, and needs. In a similar manner, attention must be paid to the valid requirements and desires of both sets of users. Finally, a mechanism should be put in place to quickly resolve conflicts between the two cultures. We acknowledge, however, that the incorporation of operational users into early programmatic decisions is difficult and that there are very few successful cases from which lessons can be derived. At the same time, the fundamental problems that arose in Global Hawk point to differences in cost/performance/schedule trade-offs. It may be possible to smooth the transition from ACTD to MDAP through earlier use of formal system engineering studies to illuminate these trade-offs to all parties, as well as through frequent updating of those analyses as real experience is gained.

[6] It is not within the power of program offices and warfighters to change annual program budgets in any significant way. Thus, cost increases can be accommodated only via schedule stretches.

A mid-ACTD program review addressing many post-ACTD program decisions would also help smooth program transitions. Basic flight testing provides a sense of the utility and direction of a post-ACTD program. Should such a program seem likely, its basic outline could be determined, allowing more time to align the expectations of current and future program participants. We note that had the original 24-month D&E phase been carried out, there would have been substantially more time to conduct a mid-ACTD program review based on preliminary flight testing, as well as more time to align the future program with the program objective memorandum (POM) budgeting cycle.

Perhaps the most important improvement to the acquisition approach would involve the establishment of a process to manage the expectations of the various organizations involved in the program. In particular, expectations regarding the possible entry point of the system into the acquisition process should be thoroughly vetted. We observe that DARPA, JFCOM, and the Air Force and Office of the Secretary of Defense (OSD) acquisition communities were strongly biased in favor of entering the acquisition process at LRIP, with varying degrees of modification. Current ACTD guidance on transitions supports this bias. However, the bias is unwarranted. Given both the technical and operational characteristics of the HAE UAV system, it should have been clear from the start that any transition would require further development, perhaps to a significant extent. The acquisition community should recognize that an important result of this type of approach might be the transfer of knowledge in the form of new operational concepts, ideas, and technologies. The user community should for their part recognize that not all systems developed elsewhere are inherently bad.

ACKNOWLEDGMENTS

This research would not have been possible without the cooperation of officials associated with the program in the U.S. Air Force, OSD, DARPA, and industry. Special thanks are due to government program office personnel and to the contractors who provided information and spent considerable time discussing the HAE UAV ACTD program.

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In addition, we would like to thank Natalie Crawford and Timothy Bonds for providing their time and resources to ensure that this research was completed to the highest-quality standards in compliance with the tenets of RAND.

Any errors are the sole responsibility of the authors.

ACRONYMS

ABCCC	Airborne Battlefield Command and Control Center
ACAT	Acquisition Category
ACC	Air Combat Command
ACC/CC	Air Combat Command Commander in Chief
ACTD	Advanced Concept Technology Demonstration; Advanced Concept Technology Demonstrator
AC2ISRC	Aerospace Command and Control and Intelligence, Surveillance, and Reconnaissance Center
AC2ISRC/C2U	Aerospace Command and Control and Intelligence, Surveillance, and Reconnaissance Center/Command and Control Directorate
AESA	Active electronically scanned array
AETC	Air Education and Training Command
AF/XORR	Air Force Director of Operational Requirements
AFFTC	Air Force Flight Test Center

AFOTEC	Air Force Operational Test and Evaluation Center
AoA	Analysis of alternatives
ARIA	Advanced Range Instrumentation Aircraft
ASC	Aeronautical Systems Center
ASC/CC	Aeronautical Systems Center commander in chief
ASC/RAV	Aeronautical Systems Center/Reconnaissance Air Vehicle
AV	Air vehicle
C4ISP	Command, control, communications, computers, and intelligence support plan
C4ISR	Command, control, communications, computers, intelligence, surveillance, and reconnaissance
CAS	Cost Accounting Standards
CDL	Contract Data List; common data link
CGS	Common ground segment
CICA	Competition in Contracting Act
CINC	Commander in chief
CLS	Contractor logistics support
CONOPS	Concept of operations; concepts of operations
COTS	Commercial off-the-shelf
CPAF	Cost plus award fee
CPFF	Cost plus fixed fee
CPIF	Cost plus incentive fee

CRS	Common Reporting System
CSAF	Chief of Staff of the United States Air Force
CSE	Computing and Software Engineering
D&E	Demonstration and Evaluation
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DAES	Defense acquisition executive summary
DAMA	Demand assigned multiple access
DARO	Defense Airborne Reconnaissance Office
DARPA	Defense Advanced Research Projects Agency
DFAR	Defense Federal Acquisition Regulation(s)
DoD	Department of Defense
DT/OT	Development test/operational test
EMD	Engineering and manufacturing development
EO/IR	Electro-optical/infrared
ESIS	Early Strategies and Issues Session
FAR	Federal Acquisition Regulation(s)
FFP	Firm fixed price
FPAF	Fixed-price award fee
FPIF	Fixed-price incentive fee
FY	Fiscal year
FYDP	Five-Year Defense Plan
GAO	[U.S.] General Accounting Office

GATM	Global air traffic management
GHSPO	Global Hawk System Program Office
GMTI	Ground moving target indicator
GPS	Global Positioning System
HAE UAV	High-Altitude Endurance Unmanned Aerial Vehicle
HQ AIA	Headquarters, Air Intelligence Agency
IMINT	Imaging intelligence
IMMC	Integrated mission management computer
INT	Intelligence
IOT&E	Initial operational test and evaluation
IPDM	Intelligence program decision memorandum
IPPD	Integrated Product and Process Development
IPRG	Intelligence Program Review Group
IPT	Integrated Product Team
ISP	Intelligence support plan
ISR	Intelligence, surveillance, and reconnaissance
ISS	Integrated sensor suite
JFCOM	Joint Forces Command
JPO	Joint program office
JROC	Joint Requirements Oversight Council
JSTARS	Joint Surveillance Target Attack Radar System

LCRS	Launch, control, and recovery station
LL	Long lead
LMSW	Lockheed Martin Skunk Works
LO	Low observable
LRE	Launch and recovery element
LRIP	Low-rate initial production
MAE	Medium-Altitude Endurance
MCE	Mission control element
MDAP	Major Defense Acquisition Program
MILCON	Military construction
MNS	Mission need statement
MoU	Memorandum of understanding
MUA	Military utility assessment
NRE	Nonrecurring engineering
OIPT	Oversight Integrated Product Team
ORD	Operational requirements document
OSD	Office of the Secretary of Defense
OT	Other Transactions
OTA	Other Transaction Authority
OT&E	Operational test and evaluation
PB	President's budget
PMD	Program Management Directive
POM	Program objective memorandum

PPBS	Planning, Programming, and Budgeting System
R&D	Research & Development
RFP	Request for proposal
RMS	Reliability, maintainability, and supportability
RSTA	Reconnaissance, surveillance, and target acquisition
RTIP	Radar Technology Improvement Program
SAF/AQ	Secretary of the Air Force for Acquisition
SAF/AQIJ	Secretary of the Air Force/Directorate for Information Dominance
SAMP	Single acquisition management plan
SAR	Synthetic aperture radar; selected acquisition report
SATCOM	Satellite communication
SCD	System capability document
SecAF	Secretary of the Air Force
SECDEF	Secretary of Defense
SEI	Software Engineering Institute
SEMP	System engineering master plan
SEPM	System engineering and program management
SETA	Systems Engineering and Technical Assistance
SIGINT	Signal intelligence
SoS	System of systems

SPO	System program office
STA	System threat assessment
STAR	System threat assessment report
TCAS	Traffic collision avoidance system
TEMP	Test and evaluation master plan
TES	Test and Evaluation Squadron
TINA	Truth in Negotiations Act
TSPR	Total system performance responsibility
UAV	Unmanned aerial vehicle
UFP	Unit Flyaway Price
USACOM	United States Atlantic Command
USD(A&T)	Under Secretary of Defense for Acquisition and Technology
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
WPAFB	Wright-Patterson Air Force Base

Chapter One

INTRODUCTION

In 1994, the Defense Advanced Research Projects Agency (DARPA), in conjunction with the Defense Airborne Reconnaissance Office (DARO), began the development of two unmanned aerial vehicles (UAVs). These systems were intended to provide surveillance information to the warfighter. They responded to the recommendations of the Defense Science Board and to the operational needs stated by DARO on behalf of military service users.[1]

UAV and tactical surveillance/reconnaissance programs have a history of failure resulting from inadequate integration of sensor, platform, and ground elements, together with unit costs far exceeding what operators have been willing to pay. Such problems have contributed to a sense of frustration and to a realization that the DoD needs to explore ways to simplify and improve the acquisition process. To overcome these historical problems, DARPA, with congressional support, adopted an innovative acquisition strategy for the High-Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) program that differed from normal Department of Defense (DoD) acquisition procedures in several important ways. These innovations are embodied in seven specific elements of the strategy: designation as an Advanced Concept Technology Demonstrator (ACTD); use of

[1]See also *Long Endurance Reconnaissance, Surveillance, and Target Acquisition (RSTA)* (JROCM-003-90, 1990), which documents a need to provide commanders in chief (CINCs) with responsive, long-endurance, near-real-time RSTA capability against defended areas; *Assured Receipt of Imagery for Tactical Forces* (JROCM-044-90, 1990), which documents a need for rapid, effective, and continuous dissemination of imagery; and *Broad Area Coverage Imaging* (JROCM-037-95, 1995), which documents a need for on-demand, near-real-time battlefield imagery.

Section 845 Other Transaction Authority (OTA); use of Integrated Product and Process Development (IPPD) and a management structure based on Integrated Product Teams (IPTs); contractor design and management authority; a small joint program office; user participation through early operational demonstrations; and a single unit price requirement with all other performance characteristics stated as goals.

The HAE UAV ACTD program consisted of two complementary system development efforts: the conventionally configured Tier II+ and the Tier III–, which incorporated low-observable (LO) technology into the design of the air vehicle. The program also included a common ground segment (CGS) that was intended to provide launch, recovery, and mission control for both air vehicles. The ACTD program was structured into three phases. Phase I was a design competition for the conventional Tier II+ system. Phase II included the development and test of both the Tier II+ (Global Hawk) and the LO Tier III– (DarkStar). Phase III involved the demonstration and evaluation (D&E) activity leading to a military utility assessment (MUA).

RAND has been analyzing the execution of the HAE UAV ACTD program's innovative acquisition strategy since the program's inception in 1994. Previous reports have documented the effects of that innovative acquisition strategy on Phase I and earlier portions of Phase II of the ACTD program.[2] The current research addresses the completion of Phase II, the transition to Phase III, and the transition to post-ACTD activities.

As the HAE UAV ACTD program transitioned to Air Force management and subsequently into the D&E phase of the ACTD, we found it useful to distinguish among three broad sets of issues: transition management; the activity content of the program; and the flight test program. This report is one of three supporting documents resulting from the current research effort; it addresses transition management issues. The other two publications address activity content and re-

[2]See Geoffrey Sommer, Giles K. Smith, John L. Birkler, and James R. Chiesa, *The Global Hawk Unmanned Aerial Vehicle Acquisition Process: A Summary of Phase I Experience*, MR-809-DARPA, Santa Monica: RAND, 1997; and Jeffrey A. Drezner, Geoffrey Sommer, and Robert S. Leonard, *Innovative Management in the DARPA High Altitude Endurance Unmanned Aerial Vehicle Program: Phase II Experience*, MR-1054-DARPA, Santa Monica: RAND, 1999.

lated program outcome issues and document the flight test program, respectively. A separate executive summary presents the main conclusions of our analysis and draws lessons regarding application of the elements of the innovative acquisition approach used in the HAE UAV ACTD program. Also provided are suggestions on ways in which the strategy can be enhanced.

OBJECTIVES

An important part of the process of improving acquisition management methods, policy, and supporting analysis lies in the accumulation of experience from ongoing or recently completed projects, especially those involving unusual situations or innovative acquisition strategies. The objective of this research was twofold: to understand how the innovative acquisition strategy used in the HAE UAV ACTD program affected the program's execution and outcomes, and to identify lessons that might be applied to a wider variety of programs in order to improve DoD acquisition strategies.

The HAE UAV ACTD program included two challenging management transitions. The first lay in the transition of management responsibility from DARPA to the Air Force within the ACTD program. The second involved the transition from an ACTD to a Major Defense Acquisition Program (MDAP) under Air Force management. Both transitions affected and were affected by the program's unique and innovative acquisition strategy. The ability to accomplish those transitions smoothly was critical to the program's success. This report explores these two challenging transitions within the context of the innovative acquisition strategy used in the HAE UAV ACTD program. Our goal was to understand the impact of that strategy on transition and associated acquisition management issues.

RESEARCH APPROACH

This project was a multiyear research effort that tracked and documented the execution of the HAE UAV ACTD program through its completion. The current research effort followed the execution of the HAE UAV ACTD program in Phase III of the ACTD, with an emphasis on transition issues, adequacy of testing, and user involvement. The overall project was organized into three tasks.

Task 1: HAE UAV ACTD Program Tracking

The primary research task was to track and document the experience of both the program office and contractors as the HAE UAV ACTD program proceeded. This task involved periodic discussions with both the Global Hawk System Program Office (GHSPO) and contractors in efforts to understand current program status, key events and milestones, and how the innovative elements of the acquisition strategy were implemented. We performed a thorough review of program documentation, including solicitations, proposals, Agreements, memoranda, and program review briefings. Through discussions and reviews of documentation, we were able to assess whether the acquisition strategy was having the expected effect as well as to identify issues arising in the course of program execution that either affected or were affected by the acquisition strategy.

Task 2: Comparisons to Other Programs

In this portion of the research, we collected and analyzed historical cost, schedule, and performance data from comparable past programs. Relatively little detailed historical data has been preserved on past UAV programs. Past UAV development efforts have tended to be canceled prior to completion, highly classified, or simple systems that are inappropriate for comparison to HAE UAVs. These circumstances make past UAV programs a poor basis for comparison to the HAE UAV ACTD. Therefore, we assembled data on program outcomes from broader databases of historical experience to assess HAE UAV ACTD program outcomes in a historical context. We examined the transition experience and test activities of other programs to provide a perspective for the strategy employed in the HAE UAV ACTD program.

Task 3: Analysis and Lessons Learned

In this task, we drew together the information collected under Tasks 1 and 2 and developed two kinds of overall results. One focused on understanding the extent to which the HAE UAV ACTD program was implemented as planned and the degree to which the program achieved its expected outcomes. The other focused on the relative success of the HAE UAV ACTD program in comparison to other pro-

grams. Together, these results yielded an understanding of the strengths and weaknesses of the overall HAE UAV ACTD acquisition strategy. We then interpreted those results in terms of lessons that might be applied to future programs.

OVERVIEW OF THE HAE UAV ACTD PROGRAM UNDER AIR FORCE MANAGEMENT

The HAE UAV ACTD program transitioned from DARPA to Air Force management on October 1, 1998, approximately one year later than planned. At the time, Global Hawk air vehicle 1 had completed five airworthiness/functional checkout sorties; air vehicle 2 was still two months from its first flight. DarkStar had resumed flight testing with air vehicle 2 only five months earlier and had completed only three sorties.[3] Phase III start was still nine months away and thus represented a substantial change from the original plan, in which the program was to have transitioned to Air Force management at the beginning of Phase III.[4] Post-ACTD planning had not yet been approved, although some small related efforts were under way in connection with the transition activities just completed. The Australian demonstration was still in the early planning and feasibility stages. At the time the program transitioned to the Air Force, the ACTD program was planned for completion in June 2000, corresponding with the completion of the MUA.

DarkStar was canceled in January 1999 and did not take part in Phase III. Northrop Grumman acquired Teledyne Ryan Aeronautical (henceforth referred to as Ryan) in July 1999. This helped resolve several important industrial-base problems, including smoothing the activity gap between the ACTD and a follow-on program; replacing the wing fabrication vendor; and providing expertise in management under a more traditional acquisition approach. This change facilitated Global Hawk's transition to an MDAP.

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[3]See Jeffrey A. Drezner and Robert S. Leonard, *Innovative Development: Global Hawk and DarkStar—Flight Test in the HAE UAV ACTD Program*, MR-1475-AF, Santa Monica: RAND, 2001, for details on the events and accomplishments of the flight test effort.

[4]This desynchronization of management and phase transition had the effect of clouding the actual transition to Phase III activities. Phase III D&E planning took place throughout the year prior to the formal start of Phase III in June 1999.

By October 2000, the ACTD program was essentially complete and the Joint Forces Command (JFCOM) had issued a positive MUA report for Global Hawk.[5] The program office was working toward a Milestone II/low-rate initial production (LRIP) decision scheduled for that month to approve entry into an initial one-year engineering and manufacturing development (EMD) program. Further work was to be based on a spiral development/evolutionary acquisition approach in which continuing nonrecurring engineering (NRE) activities resulted in scheduled block upgrades. The October 2000 Defense Acquisition Board (DAB) II was delayed until December 2000 as a result of continued disagreement regarding the specifics on the evolutionary approach (i.e., requirements and capabilities associated with each block, timing, and quantities). The December 2000 DAB II did not take place. Milestone II finally occurred on March 6, 2001.

Five Global Hawk air vehicles, three launch and recovery elements (LREs), and two mission control elements (MCEs) were fabricated and tested to varying degrees. Global Hawk air vehicle 2 was destroyed on March 29, 1999; it was carrying the only integrated sensor suite (ISS) acquired up to that time. Air vehicle 3 experienced a postflight taxi mishap on December 6, 1999, destroying the program's only remaining electro-optical/infrared (EO/IR) sensor and delaying the flight test program by three months as flight test management was reorganized. Global Hawk participated in 11 formal exercises as part of the Phase III D&E program supporting the MUA.

Residual assets at the end of the ACTD included four Global Hawk air vehicles, two synthetic aperture radars (SARs), one ISS (purchased after the destruction of the first ISS), two MCEs, and three LREs. Two additional air vehicles (air vehicles 6 and 7) will be delivered in FY 2002; these will have a somewhat different configuration than previous air vehicles, requiring modifications to the ground segments.

Over the 30 months from October 1998 to March 2001, the Air Force program office was occupied with three simultaneous primary management tasks: conducting the flight test program; planning for a transition from ACTD to the traditional acquisition process; and re-

[5]JFCOM is the renamed United States Atlantic Command (USACOM) with additional responsibilities in requirements development and experimentation. The final MUA was dated September 2000.

quirements generation and concept-of-operations (CONOPS) development, especially as it related to post-ACTD activities. In all these efforts, the innovative acquisition approach that characterized the program under DARPA management continued to have a significant effect on program management, events, and outcomes. In particular, the program's designation as an ACTD, its use of Section 845 OTA, and the lack of firm performance requirements had the greatest influence on the two transitions.

ORGANIZATION OF THE REPORT

The remainder of this report presents information relating to the two management transitions—from DARPA to Air Force management and from ACTD to MDAP status—and the effect of the program's innovative acquisition strategy on those transitions. In the course of this discussion, information on key acquisition management issues and program events is also presented, with an emphasis on the effect of the program acquisition strategy.

Chapter Two discusses the management transition from DARPA to the Air Force. Evidence suggests that this transition was remarkably smooth.

Chapter Three documents the key issues and events surrounding the transition of Global Hawk from an ACTD program to the formal acquisition process. Aside from managing the flight test program, much of the program office's effort was focused on this more challenging and problematic transition. We give particular attention to how the post-ACTD program structure has evolved to date and the influence of the ACTD-era acquisition strategy on those plans.

Chapter Four summarizes the impact of the acquisition strategy on transition management; lists the key factors affecting the relative success of the two transitions; and suggests several improvements to the acquisition strategy which might help overcome the transition-related problems encountered in the HAE UAV ACTD program.

Chapter Two

TRANSITION FROM DARPA TO AIR FORCE MANAGEMENT

The original HAE UAV ACTD program plan anticipated a transition of management responsibility from DARPA to the Air Force at the end of Phase II. Engineering development and associated flight testing were to have been completed by this time. It was believed that Air Force management of Phase III D&E activities would facilitate the eventual transition of the program to an MDAP and deployment. The program would still be an ACTD when management responsibility was transferred; authority to continue the innovative acquisition strategy used in the program would also transfer to the Air Force. This transition was unusual in that most ACTDs had a single institutional manager, with a transition to another organization for post-ACTD activities.

The transition from DARPA to the Air Force was completed on October 1, 1998, approximately one year later than planned. It would appear that this slip in schedule, which was driven by technical problems that caused delays in the initiation of Phase II flight testing, did not adversely affect the transition. However, engineering development and associated flight testing had not been completed and in fact had just begun.[1]

[1]Global Hawk air vehicle 1 had completed five flights at the time of transition. DarkStar air vehicle 2 had completed three flights.

The transition itself was relatively smooth. Many of the factors that facilitate a smooth interagency program transition were present.[2] A survey of DARPA transitions to the military services, industry, and other government organizations suggests that a clearly stated need, a good working relationship among project participants, persistence, joint support, user support, and early transition planning are among the factors contributing to a successful transition.[3] The following can be said to characterize the HAE UAV ACTD program:

- The program addressed a validated need.
- The Air Force was designated the lead agency for Phase III and follow-on in the original memorandum of understanding (MoU) establishing the program.
- The transition point and associated criteria were identified in the earliest management plans.
- Air Force personnel had been integral to the program, and a supporting program office was established early in the program.
- The transition itself was well planned and documented in a series of issue papers, briefings, and interagency agreements.

The original HAE UAV ACTD program MoU, dated October 1994, laid the groundwork for a successful transition from DARPA to Air Force management. It assigned an Air Force colonel and a Navy captain as deputy program managers. The MoU itself was iterated among the staff of the relevant DoD and service organizations, and the rationale for the program was based on a validated Joint Requirements Oversight Council (JROC) mission need statement (MNS) for recon-

[2]See Richard O. Hundley and Eugene C. Gritton, *Future Technology-Driven Revolutions in Military Operations*, DB-110-ARPA, Santa Monica: RAND, 1994; Defense Advanced Research Projects Agency, *DARPA Technology Transition*, Arlington, VA, 1998; Sidney G. Reed, Richard H. Van Atta, and Seymour J. Deitchman, *DARPA Technical Accomplishments: An Historical Review of Selected DARPA Projects*, Alexandria, VA: Institute for Defense Analyses, IDA-P-2192, Vol. 1, February 1990; and Richard O. Hundley, "DARPA Technology Transitions: Problems and Opportunities," internal document, Santa Monica: RAND, 1999.

[3]See Defense Advanced Research Projects Agency, *DARPA Technology Transition*, 1998, p. 20.

naissance, surveillance, and target acquisition (RSTA).[4] The initial MoU also mentioned the principle of event-based timing and associated the transition to Air Force management with the completion of Phase II. The Air Force was identified as the lead agency for Phase III and beyond, and service deputy program managers were intended to transition with the program along with other service-specific billets supporting the program. Service roles and responsibilities were also laid out. The very structure of the plan—transitioning management to the lead agency during the ACTD program—was intended to facilitate successful transition to the formal acquisition process and to operational users.

Transition planning began early. A supporting office at the Aeronautical Systems Center (ASC) at Wright-Patterson Air Force Base (WPAFB) was established in November 1995, although logistics issues were being supported as early as August 1995. The ASC program office was intended to be a shadow organization to monitor and support HAE UAV progress. In fact, personnel from the ASC program office have been key in all HAE UAV ACTD program activities; the organization charts from the DARPA and ASC offices listed many of the same personnel. Many but not all of the key management personnel in the ASC program office did in fact remain in their positions at the time of the transition. Thus, some of the learning that had taken place under DARPA leadership regarding both the management (i.e., acquisition strategy) and technical aspects of the program was preserved.

The July 1996 transition plan—which was signed by the DARPA and Air Force principals—outlined the general transition approach, established a working group to update the transition plan and resolve issues, and directed the development of a lessons-learned database. Key decisions affecting the program transition required the approval of both the DARPA director and the ASC commander at WPAFB. Transition activities were defined in the following areas:

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[4]See *Long Endurance Reconnaissance, Surveillance, and Target Acquisition (RSTA)*, 1990.

- **Technical:** risk assessment and continuity of technical knowledge;
- **Financial:** funding;
- **Contracts:** contractual mechanisms;
- **Test and demonstration:** residual tasks and assets;
- **Supportability:** reliability and maintainability; and
- **Programmatic:** coordination with related programs.

The original management plan (dated December 15, 1994) identified the transition from DARPA to Air Force management as occurring in the third quarter of FY 1997, coinciding with the beginning of Phase III. The original program schedule chart indicates the planned transition occurring in April 1997—roughly halfway through the engineering flight test of the conventional UAV, six months before the beginning of the user demonstration, and two-thirds of the way through a limited demonstration activity for the LO UAV, which at that time was further along in development.[5] At this time, a 12-month engineering flight test was planned and was to be followed by a 24-month user demonstration. Subsequent plans adjusted both the transition date and the lengths and start dates of the two flight test components. However, the transition was always associated with the completion of Phase II activities, which included the delivery and engineering flight test of two conventional UAVs and two LO UAVs. The actual management transition took place on October 1, 1998, well into development test but several months prior to its completion.[6]

The apparent smoothness of the transition from DARPA to Air Force management belies some important problems. First, while most of the ASC shadow program office did transition, many core person-

[5]These dates are not inconsistent: The beginning of the third quarter of FY 1997 is April 1997.

[6]For a more detailed description of flight test schedules and activities, see Drezner and Leonards, *Innovative Development: Global Hawk and DarkStar—Flight Test in the HAE UAV ACTD Program*, 2001. See also Drezner, Sommer, and Leonard, *Innovative Management in the DARPA High Altitude Endurance Unmanned Aerial Vehicle Program*, 1999, Figure 3.3, p. 55.

nel—both government and Systems Engineering and Technical Assistance (SETA) contractor—did not. Because these new personnel were unfamiliar with the management approach being used, some time and effort were required to bring them up to speed. Second, although the general management approach remained similar, the Air Force style was very different from that of DARPA, as reflected in communication between the system program office (SPO) and contractors as well as in required program documentation. Financial management practices differed significantly as well; the Air Force tended to be somewhat more meticulous in tracking obligations and expenditures and required more accountability. Additionally, while the Air Force program office was initially smaller than the DARPA joint program office (JPO), the former grew considerably as the program progressed; thus, there were variations in interpreting and executing the management approach that did not exist in the small DARPA program office. For instance, whereas there were two Agreements officers in the Air Force SPO, under DARPA there was only one Agreements officer for all three segments. Finally, the Air Force personnel associated with the program in its early stages were predominantly from the acquisition community. By contrast, Air Combat Command (ACC) personnel were not deeply involved until flight test began, and then only a small contingent (the 31st Test and Evaluation Squadron [TES]) at Edwards Air Force Base were actively involved. Thus, the operational user was not involved in transition planning. This would later cause significant tension as the program approached its second transition from ACTD to MDAP status.

As Phase II engineering flight testing proceeded under DARPA, senior Air Force managers who were to assume responsibility for the program in FY 1999 began to express some uneasiness with elements of the acquisition strategy used in the HAE UAV ACTD program. One reason for this unease was that many of the senior Air Force officials who had originally been involved with the program had moved on. This illustrates both the difficulty and the importance of maintaining a consistent management approach during and after a transition. This issue was only partially resolved through briefings by the DARPA program director to key Air Force officials prior to the actual transition. These briefings came somewhat late in the process and did not fully succeed in obtaining buy-in from Air Force decisionmakers.

Nevertheless, the Air Force did retain the key elements of the acquisition strategy. This may be due in part to senior leaders' recognition that the program was important both in terms of the system's capability and as a demonstration of acquisition reform.

Air Force Program Management Directive (PMD) 2404, issued May 25, 1999 (eight months after formal management transition), delineated the roles and responsibilities of the various organizations involved with the HAE UAV. The PMD states that both Global Hawk (RQ-4A) and CGS (AN-MSQ-131) were managed out of the same program office in ASC. Program participants included the following:

- **The Secretary of the Air Force/Directorate for Information Dominance (SAF/AQIJ)** serves as the secretariat (civilian) focal point for the HAE UAV ACTD program in the Pentagon and coordinates all acquisition management, policy, and investment budget matters.
- **The Air Force Director of Operational Requirements (AF/XORR)** serves as the Headquarters U.S. Air Force (military) focal point, coordinates all operational matters (including support and operations budgets), and coordinates preparation for post-ACTD integration of the HAE UAV into the force structure.
- **The Aeronautical Systems Center/Reconnaissance Air Vehicle Directorate (ASC/RAV)** provides overall execution and management for the development, fabrication, test, and evaluation of the HAE UAV ACTD system; coordinates with test organizations; assists in operational requirements document (ORD) development; continues technology development for future application to the HAE UAV; and supports post-ACTD planning.
- **The Aerospace Command and Control and Intelligence, Surveillance, and Reconnaissnce Center/Command and Control Directorate (AC2ISRC/C2)** supports the HAE UAV ACTD program through participation in planning activities, review meetings, and the like; establishes a prioritized list of system improvements; develops a CONOPS and an ORD; conducts an analysis of alternatives (AoA); and serves as the focal point for basing, force structure, personnel, and military construction (MILCON).

- **Detachment 1, Air Force Operational Test and Evaluation Center (AFOTEC)** plans and executes the MUA with the United States Atlantic Command (USACOM) and participates in planning and review activities.
- **The Air Force Flight Test Center (AFFTC)** provides the infrastructure to support flight testing and participates in planning and review activities.
- **The Air Education and Training Command (AETC)** participates in the training of IPTs and plans and conducts training for the life-cycle support of the system.
- **Headquarters, Air Intelligence Agency (HQ AIA)** develops an intelligence support plan (ISP) and a system threat assessment (STA)/system threat assessment report (STAR).

Clearly, the major Air Force players were ASC/RAV, AC2ISRC, and AFOTEC; these organizations are responsible for program execution and post-ACTD planning.

Some issues that arose in the course of planning for the transition were not completely addressed or determined by the time of the actual transition. These included the operational maintenance concept; post-ACTD activities, funding, and management/contractual issues; the relationship and roles of the ACTD and MDAP users (USACOM/JFCOM and ACC); and the status of residual program assets. These would become significant issues as attention focused on the transition from ACTD to MDAP. However, the majority of the work required to successfully execute Phase III user demonstrations had been resolved: completing engineering tests, user demonstration schedule and planned assets, and data collection and assessment leading to the MUA. The authority to use the innovative acquisition strategy transitioned to the Air Force along with program management responsibility.

With the exception of the time needed for new personnel to learn to manage under the program's different approach, the innovative acquisition strategy used in the HAE UAV ACTD program appears not to have greatly affected the transition from DARPA to Air Force management. The flexibility inherent in the strategy may have allowed for easier adjustment as the program progressed through Phase I and

Phase II, but the factors chiefly responsible for the smooth transition (early planning, inclusion of the lead service as a critical partner from the beginning, and sustained top-level support from participating agencies) could be present in any program's acquisition strategy.

In contrast, the program's innovative acquisition approach had a profound effect on the transition from an ACTD to an MDAP.

Chapter Three

TRANSITION FROM ACTD TO MDAP

THE TRANSITION CHALLENGE

The transition from ACTD program status to the formal acquisition process was challenging. This challenge derived in part from the constraint in early program documents that obligated the Air Force to transition the ACTD program to an MDAP Acquisition Category (ACAT) IC program managed under more traditional acquisition regulations and procedures.

The challenge also derived in part from the partially developed state of the system at the end of the ACTD. At this point, the system was neither fully developed (i.e., ready for production) nor simply a technology demonstrator, a prototype, or an operational demonstrator ready for a complete EMD phase. Instead, the system's developmental maturity fell somewhere in between these typical Milestone I and Milestone II development states, complicating the issue of entry into the formal acquisition process and subsequent post-ACTD activities. Additional challenges arose because the initial plans and development efforts were formulated and executed at DARPA, not the Air Force, using a highly innovative and radical approach.

In contrast to the earlier transition from DARPA to Air Force management within the ACTD construct, the transition to an MDAP was not as well planned prior to the actual initiation of transition-related activities. Additionally, the issues involved in the transition to post-ACTD activities were more complex. These included the following:

- The management approach in the ACTD program required significant modification for the traditional MDAP environment. Both contractor and GHSPO officials needed to make the cultural change back to the more traditional approach. Almost every element of the innovative approach used during the ACTD needed to be changed. Complicating this issue were significant changes to the traditional or standard approach as embodied in the recently revised DoD 5000 series regulations.[1]
- The expectation of an MUA point decision at the end of the ACTD program conflicts with the Planning, Programming, and Budgeting System (PPBS) process. The MUA and budgeting processes are significantly out of sync, resulting in poor planning for future funding. This issue was complicated by continued disagreement as to when, how, and in what form Global Hawk should be incorporated into the force structure.
- There was no approved requirements documentation to guide post-ACTD planning. MDAPs are founded on a firm ORD that specifies in some detail the capabilities and performance attributes expected of the system. The ACTD program produced no equivalent document. The organization with institutional responsibility for requirements during the ACTD (JFCOM) was entirely separate from the post-ACTD organization responsible for requirements (ACC). JFCOM and ACC have very different perspectives on what constitutes useful capability. The result was extended disagreement as to precisely what system should be developed and procured (i.e., configuration and capabilities).

These issues strongly interacted with each other.

Transitioning from relatively low level development activities in which future production is not assured to development activities whose intent is to produce and field a system constitutes a significant challenge. Reporting and oversight concerns and intensity change; funding levels usually increase substantially; contracting strategies adjust; test and evaluation results must be incorporated into ongoing development and production activities; user involvement intensifies;

[1]See DoD Policy 5000.1, Instruction 5000.2, and Regulation 5000.2R, dated January 4, 2001.

system capabilities and upgrades are measured and defined more precisely; and supportability concerns become more prominent. These normal challenges were significantly intensified for the HAE UAV ACTD program as a result of the management approach used in the program.

HAE UAV SYSTEM COMPLEXITY

Two characteristics of the HAE UAV weapon system concept and management particularly complicated the transition from an ACTD to a tailored EMD phase within an MDAP.

First, Global Hawk is in essence a system of systems (SoS) composed of an air vehicle and ground segment whose utility depends wholly on its ability to interact with other command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems (for dissemination of imagery). Global Hawk thus faces a set of SoS issues that the DoD as a whole is only beginning to recognize, including technical interoperability with legacy and future planned systems; CONOPS (what external systems should Global Hawk depend on and be linked to?); and the synchronized evolution of requirements and capabilities. The spiral development/evolutionary acquisition approach that the post-ACTD Global Hawk will use requires the coevolution not only of requirements and operational concepts but also of budgeting, training, and support concepts as the system evolves and new technologies and capabilities are introduced.[2] While this is an appropriate conceptual model for Global Hawk, there is no prior experience within the DoD to inform the design and execution of the post-ACTD program.

[2]The spiral development approach is based on the notion of continuous incremental development. It is a developmental approach consistent with an evolutionary acquisition strategy, as embodied in the latest revisions to the DoD 5000 (January 4, 2001) series acquisition policy. Technically, spiral development and evolutionary acquisition are different; the former refers to a specific methodology for developing software and the latter to an acquisition strategy concept. However, both are iterative, risk-based incremental approaches to system design and development. See Barry W. Boehm, "A Spiral Model of Software Development and Enhancement," *Computer*, May 1988, pp. 61–72, and *Spiral Development—Building a Culture*, a report of the Computing and Software Engineering Software Engineering Institute (CSE SEI) Workshop, CMU/SEI-2000-SR-006, February 2000.

Second, the GHSPO is unique in that it is responsible for acquiring—and in some cases developing—all systems that constitute the capability of the HAE UAV weapon system concept. This includes responsibility for the engines, communications systems, payloads, air vehicle, and ground segments (both the LRE and the MCE). In more traditional programs, many of these items are developed and procured outside the immediate program office responsibility. The GHSPO must transition more than just an aircraft from the innovative strategy to a more traditional Federal Acquisition Regulation (FAR)-based approach.

Finally, there is no established process to guide the transition either from an ACTD to a tailored EMD phase or directly to production. Some program participants believe that this is a flaw in the ACTD concept. Indeed, there is substantial evidence that a focused EMD phase is needed to address operational issues identified with the ACTD configuration through the experience gained during engineering and operational demonstration flight testing. Global Hawk may be the first ACTD program to reach a Milestone II decision and thus well illustrates the difficulties inherent in such a transition.

POST-ACTD PLANNING

The issue of canceling DarkStar and beginning post-ACTD planning for Global Hawk was first formally raised at a January 1999 meeting with Under Secretary of Defense for Acquisition and Technology (USD [A&T]) Jacques Gansler. The cancellation of DarkStar had been informally discussed among Office of the Secretary of Defense (OSD) and Air Force officials since early 1998, but a decision was deferred until some flight testing was accomplished. The contractors (Lockheed Martin Skunk Works [LMSW] and Boeing) were formally ordered to cease activity on January 29, 1999.[3] Post-ACTD planning for the HAE UAV program had been explicitly delayed until after this decision was made. The termination of DarkStar soon after the management transition from DARPA to the Air Force enabled the latter to focus its efforts on a single system rather than two. The program office received permission to begin post-ACTD activity plan-

[3]SAF/AQ memorandum for ASC/CC, Subject: DarkStar Termination, January 29, 1999.

ning for Global Hawk in early 1999, late in the ACTD program. The planned go-ahead date was June 2000, coinciding with the release of the MUA and the completion of Phase III D&E.

Laying Out Options

Phase III execution of the HAE UAV ACTD program was based on guidance in the ACTD management plan.[4] This plan was almost one year old when the Air Force assumed responsibility for the program. It included very little post-ACTD content; at the time it was written, DarkStar was still an active component of the program.

Guidance and direction for post-ACTD activities were eventually documented in the single acquisition management plan (SAMP). Reflecting a high level of uncertainty, the initial draft SAMP for Global Hawk (released in May 1999) left many basic program management issues unresolved, including the nature of further development activities; procurement quantities and timing; the use of OTA or a more traditional process; and test planning. ACTD accomplishments were not emphasized, giving the first indication that post-ACTD program management would be unlike the innovative approach that had been used up to that point. Global Hawk funding plans as of July 1999 included $420 million in the current Five-Year Defense Plan (FYDP) and $25 million reallocated by Congress to cover fourth-quarter FY 2000 program activities (not ACTD). The initial draft SAMP mainly provided a framework for planning the future program. It was drafted under the following constraints:

1. Phase III of the ACTD was not that far along, and informal post-ACTD planning had begun only two months before. There was a high degree of uncertainty associated with the future of Global Hawk (i.e., with regard to budgets, quantities, and requirements). This uncertainty would be alleviated over time, and new information would be used to improve the SAMP contents as uncertainties were reduced.
2. The Air Force was forced to plan for a traditional MDAP ACAT I program because:

[4]See *HAE UAV ACTD Management Plan*, version 6.0, December 1997.

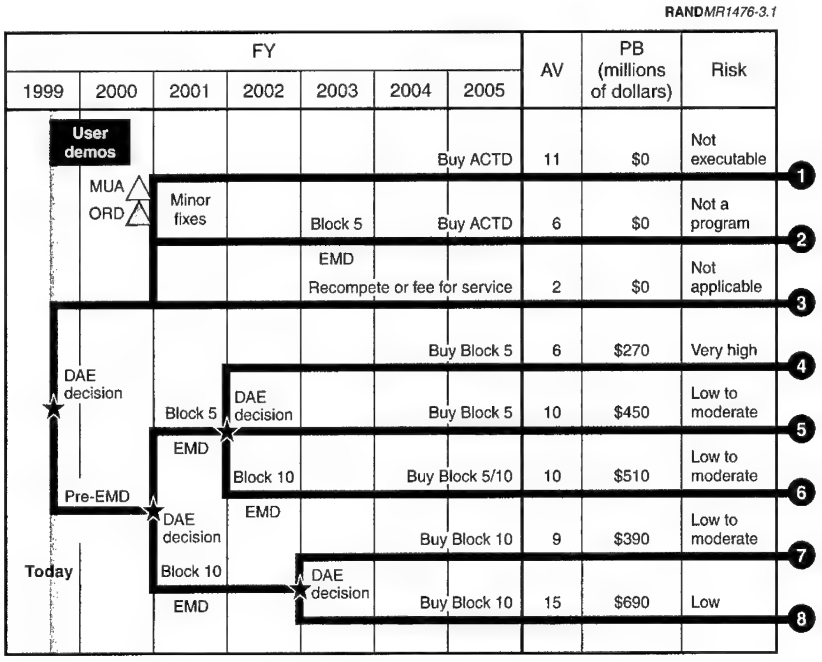
- It had a need to get organizational buy-in to continue the program. This would be easier if the program took on a more traditional approach.
- There was no guarantee of continued OTA, especially for production.
- Provisions for an MDAP ACAT IC program were mandated in earlier plans, in part to preserve the difference between the ACTD and MDAP processes.[5]

The planned one-year EMD program complied with congressional direction from the FY 1999 Authorization Conference Report, stating that Global Hawk could not enter production until an EMD phase had been completed.

Follow-on options for Global Hawk were requested by the Assistant Secretary of the Air Force for Acquisition (SAF/AQ) and OSD. Over the period May–June 1999, the program office prepared ten different options representing a range of strategies. In the workup to a July 1999 USD(A&T) program review, the Oversight Integrated Product Team (OIPT) requested a "do less" option. The GHSPO decided that "less" meant half the cost and thus developed a proposed EMD phase with NRE efforts costing approximately $30 million, leading to a Block 5 configuration. This was the first manifestation of the Block 5 configuration. Eight options were presented to the USD(A&T) at the July 1999 program review (see Figure 3.1).

As Figure 3.1 indicates, the options presented ranged from buying the ACTD configuration with no additional funds beyond those already programmed to moving to a two-year EMD to develop and procure the Block 10 configuration with a budget plus-up of $690 million. The options also varied in the number of and timing of subsequent milestone decision points and in the number of air vehicles to be procured (two to fifteen). Many of the options included the Block 5 configuration representing the must-fix items for the user, eventually leading to a fully ORD-compliant Block 10. This is some-

[5]An ACTD is considered a preacquisition program and not part of the acquisition process. One critique of ACTDs, particularly from Congress, was that they were the DoD's way of bypassing traditional approval processes for starting the development and acquisition of a new system.



Options 3, 7, and 8 being considered by IPRG.

Figure 3.1—July 1999 Post-ACTD Program Options

what misleading in that an ORD defining Block 10 did not yet exist, although a draft ORD was in progress.

The USD(A&T) program review was held on July 7, 1999. The resulting decision memorandum was signed on July 11, and was received in the GHSPO on July 15. The essence of the decision on Global Hawk was that some EMD would be required, but the structure of the future program was left undefined. The result was a focus on three of the options presented at the program review:

- **Option 5:** A $450 million increase above the FY 2001 program objective memorandum (POM); a one-year limited EMD; production of two Block 5 air vehicles per year with fielding beginning in FY 2003; eight air vehicles and two CGSs procured within the FYDP; and deferral of Block 10 to outside the FYDP. This

program option was rated as executable at low to moderate risk. It was recognized that Block 5 would not meet many of the draft requirements embodied in the draft ORD.

- **Option 6:** A $510 million plus-up to the FY 2001 POM; concurrent development and production; the building of two Block 5 air vehicles; a two-year EMD leading to Block 10; and production of six Block 10 systems to be procured within the FYDP along with procurement of two CGSs. This option was also rated by the GHSPO as executable at low to moderate risk. The draft ORD requirements would be satisfied by the Block 10 configuration.
- **Option 7:** A $390 million plus-up to the FY 2001 POM; a two-year full EMD; production of two Block 10 air vehicles per year beginning in FY 2003, with one EMD Block 10 built prior to the production units; and procurement of six Block 10 air vehicles and one CGS within the FYDP. This option, which would meet most of the requirements in the draft ORD, was rated as executable at moderate risk.

The options varied in terms of required funding and resulting air vehicle capability, but each included an ACTD transition period, two additional ACTD-configuration air vehicles (air vehicles 6 and 7), and a two-aircraft-per-year production rate. As a result of the program review, pre-EMD activities were approved and authority was granted to define EMD activities in more detail.[6] Theoretically, the program could still be canceled in June 2000 if JFCOM released a negative MUA, but this was considered highly unlikely. An EMD Milestone II decision was tentatively planned in one year (June 2000), corresponding to the end of the ACTD.

July 1999 was the first time the broad outlines of a post-ACTD acquisition strategy had been defined. This gave the program office only one year to finalize the plan and prepare all the required documentation. More significantly, Air Force support for the program would need to be developed in the same time frame, particularly in ACC.

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[6]See Global Hawk review charts, July 7, 1999, and USD(A&T) memorandum for the Secretary of the Air Force, Subject: Global Hawk Decision Memorandum, July 11, 1999.

Choosing One Option and Underfunding It

Although the broad outline of the post-ACTD program remained fairly constant, there were continuous changes in implementation detail over the subsequent year.

Intelligence Program Decision Memorandum (IPDM) 1 dated August 20, 1999, provided guidance on the structure of the MDAP and formed the basis of subsequent planning:

- Buy two aircraft in FY 2001 (air vehicles 6 and 7) and protect the industrial base.[7]
- Initiate a one-year EMD program beginning in FY 2001.
- Begin aircraft production in FY 2002 at a rate of two per year, including minimum required operational upgrades.
- Use a spiral development approach to satisfy the ORD and address issues to be raised in the MUA.

There remained some debate about exactly how to implement this guidance, including funding profiles, the activity content of EMD and other pre- and post-ACTD NRE activities, and how the ORD would relate to spiral development.[8] This last issue, discussed more fully in a subsequent section, concerns the establishment of a technical and performance baseline for the system.

The Deputy USD(A&T) called a meeting in September 1999 with all the principals involved in Global Hawk to ask for a decision on the future program. After some discussion, he proposed a $510 million plus-up to the FYDP to cover a one-year EMD program and the production of Block 5 air vehicles as well as a follow-on EMD program and the production of Block 10 air vehicles. The Air Force was not

[7]The industrial base was implicitly defined as Ryan Aeronautical Center for large, high-endurance UAVs.

[8]The concept of spiral development is based in large part on the spiral model of software development created by Barry Boehm in 1988. In essence, the spiral model is a risk-based, iterative approach to development in which the specific activities and associated requirements of one cycle are based on the results of the previous cycle. Spiral development would of necessity need flexible and evolutionary requirements rather than fixed requirements or specifications. See Boehm, "A Spiral Model of Software Development and Enhancement" May 1988, pp. 61–72.

pleased with the plus-up, since it would require the transfer of funds from other programs. The Air Force Vice Chief of Staff later asked for only a $390 million plus-up to the POM line for Global Hawk but promised to accomplish the same program content. This decision resulted from the ever-present budget pressures the Air Force faced as it struggled to incorporate Global Hawk. It also suggests that post-ACTD activities would be underfunded from the start.

The precise configuration of Blocks 5 and 10 remained somewhat open-ended. There was no direction regarding specific content. The plan was to baseline the configuration after the one-year EMD through a subsequent spiral development approach (an iterative, risk-based methodology originally created for software development). Capability would be improved in each succeeding block upgrade (or spiral).

Program officials were expecting to heavily tailor EMD activities. LRIP authority would be requested at Milestone II. The required operational test and evaluation (OT&E) in EMD would be tailored on the basis of the accomplishments of the D&E program supporting the MUA and the spiral development approach (testing should parallel the evolving requirements and performance goals). A waiver of the live-fire testing requirement was requested and eventually granted. The Acquisition Deskbook was used to develop a list of required documents supporting the Milestone II decision and the transition to the traditional acquisition process.[9] The Global Hawk program was required to generate all the documents normally produced as part of the formal acquisition process.

The AoA briefed to senior Air Force decisionmakers on January 14, 2000, described an EMD phase with NRE activities valued at roughly $68 million leading to Block 10 capabilities. The AoA recommended upgrades to the radar, mission planning,[10] common data link, supportability, ultra-wideband satellite communication (SATCOM), and survivability suite. A draft ORD released the same month by AC2ISRC incorporated the AoA recommendations. Final coordina-

[9]See www.acq.osd.mil.

[10]Mission planning refers to flight profiles and sensor tasking. In an autonomous UAV, the time it takes to develop and validate a mission plan is driven by the need for contingencies (alternate mission profiles; alternate approach paths and landing sites).

tion and approval of the ORD were expected to occur in June 2000. The initial CONOPS and the MUA were expected to be completed around June 2000 as well.

As of March 2000, remaining program risks included the following:[11]

- All requirements had not yet been defined.
- Resource constraints allowed either EMD or contingency deployments but not both.
- Funding was insufficient to support concurrent EMD and production.
- Facility constraints in terms of ramping up production rates remained.
- Insufficient funding was programmed for beyond Spiral 1 (Block 5) development.
- Technical data and training may not be complete by initial operational test and evaluation (IOT&E).
- The program faced the potential unavailability of parts due to vanishing vendors, particularly for some of the commercial off-the-shelf (COTS)-based systems.
- Global Hawk systems available for IOT&E might not be the production-representative configuration required.

Although the OIPT indicated its general approval of the planned Milestone II, IOT&E, and LRIP approach in April 2000, the milestone decision had slipped by two months and was now scheduled for September 27, 2000.

Briefings to senior groups and officials increased as work toward the Milestone II decision continued. Many program officials noted that the Global Hawk program was receiving the same visibility as the F-22 and C-17 programs, which were many times larger in terms of both dollar value and program office size.

[11]ASC/RAV Early Strategies and Issues Session (ESIS) briefing, March 2000.

As of February 2000, the acquisition strategy based on the August 1999 IPDM had a Milestone II decision planned for July 2000, marking the official end of the ACTD. A Milestone III decision would occur roughly one year later. In this plan, there was a gap between EMD completion and the Milestone III decision. The program office wanted the July 2000 decision to be a combined Milestone II/Milestone III LRIP, with resulting air vehicles in the "production configuration." The result was a disconnect between the strategy directed in the IPDM, the way in which that strategy would actually be implemented, and what made developmental sense. This disconnect was reflected in the various "implementation schedules" developed by the GHSPO over the year leading up to the Milestone II decision.

The various draft implementation schedules added some detail to the post-ACTD program structure. Most of them showed continuing NRE activities put on contract prior to the completion of the ACTD. Most also showed a one-year EMD period preceded by "pre-EMD" activities. Long-lead approval for aircraft in the Spiral 1 (Block 5) configuration was planned for the middle of FY 2001 (during EMD). An LRIP decision was expected at the beginning of FY 2002. Air vehicles 6 and 7, which were put on contract in December 1999,[12] were to be delivered in FY 2002, after the one-year EMD was complete. The first production Block 5 aircraft would be delivered in FY 2003. Most of these schedules showed a two-aircraft-per-year production rate through FY 2006 and two additional complete ground segments (LRE and MCE) being fabricated and delivered beginning in FY 2003. IOT&E was to take place in FY 2003. Milestone III (full-rate production) was planned for the beginning of FY 2002 or later (FY 2004) on some versions of these charts. Milestone III was sometimes replaced by a program review.

Taken as plans, these alternative schedules illustrate some critical execution gaps and problems, including the following:

- The EMD phase was very short and appeared to be disconnected from other elements of the program, particularly the continuing NRE activities and the Australian demonstration.

[12]The amendment officially adding this activity to the program was not signed off until February 2000.

- No EMD aircraft or modified ACTD configuration systems supported the one-year EMD.
- IOT&E was planned to begin in the third year after the start of EMD, initially with only air vehicle 7 (the ACTD configuration) in its support.[13]
- There was no indication of subsequent development efforts (e.g., Spiral 2/Block 10).[14]
- The Australian demonstration was to be conducted in parallel with EMD, thereby taxing both the government and contractor program offices while occupying available resources.
- Four aircraft (two ACTD configurations [air vehicles 6 and 7] and two Block 5 configurations [P-1 and P-2]) were to be produced prior to IOT&E.
- No changes in production rates were to result from a Milestone III decision, raising the question of why such a decision point is needed.

The variations in the basic post-ACTD program as embodied in the myriad versions of these implementation schedules illustrate the volatility of the acquisition strategy at this time. Several months past the initial June 2000 Milestone II decision point and just days before a planned October 2000 DAB, these implementation schedules were still changing.

The ambiguity surrounding future funding and requirements (and associated capabilities) for post-ACTD activities was the dominant variable affecting planning. However, other issues also complicated post-ACTD planning; guidance was lacking in critical areas. In March 2000, for example, guidance was still needed regarding the use of OTA for production (OTA use for EMD was still presumed at this time); for the maintenance concept (Air Force support versus contractor logistics support [CLS])[15] and its effect on total system

[13]Air vehicle 7 will be backfit to incorporate many of the EMD changes.

[14]Subsequent program activities were discussed in the SAMP.

[15]Although the Secretary of the Air Force (SecAF) had provided direction to use CLS in January 2000, this issue remained unresolved.

performance responsibility (TSPR), technical orders, and training; for guidance on deployment and contingency plans on the use of residual assets; and for the selection of the main operating base.[16]

The production rate of two aircraft per year, combined with the long lead time of six months (a 24-month total production cycle), the fabrication of additional ground segments, and continuing NRE activities, certainly raised the question of changes in configuration. Each pair of ACTD aircraft and each additional ground segment represented a somewhat different configuration as the results of NRE were incorporated. The interoperability of program assets (e.g., backward compatibility) was a concern.

Global Hawk Configuration Changes

It is important to recognize that Global Hawk has been engaged in continuous, iterative development throughout the ACTD program. Phases II, IIB, III, and IIC all included NRE activities. Those NRE activities were based on knowledge gained during earlier activities, and the results of the NRE were incorporated into the design and fabrication of subsequent ACTD systems. The Block 1 configuration is that of ACTD air vehicles 4 and 5. The Block 2 configuration is that of ACTD air vehicles 6 and 7. The changes in these aircraft from the initial three are ACTD configuration improvements initiated by the contractor, as Ryan had configuration control during the ACTD. This represents an implementation of spiral development, which Global Hawk has been doing all along.

Air vehicles 6 and 7 were fabricated as part of Phase IIC and will be delivered in FY 2002. These air vehicles include improvements resulting from the continuous NRE activities conducted during Phase III. All ACTD systems will eventually be modified to the Block 2 configuration. The ACTD vehicles will not, however, be interoperable with the production configuration. Air vehicle 7 will be upgraded to approximate the production configuration and will support the initial one-year EMD; this ACTD system will not be interoperable with the other ACTD systems.

[16]These issues had all been worked by the time of formal transition to MDAP status.

The continuous nature of development activities during the ACTD also brings into focus a basic conflict underlying much of the debate regarding post-ACTD planning. In the traditional acquisition process, Milestone II is considered entry into development. Yet Global Hawk has been under development since the ACTD Phase II award. This is a basic conflict: Is the post-ACTD Global Hawk a new start or simply a continuation of ongoing activities? We believe the activities of the program clearly show it is the latter. However, this question has not been answered in a way that has satisfied the various program participants.

For Global Hawk, the initial post-ACTD step is from the ACTD configuration to a Block 5 (Spiral 1) configuration. Spiral 1 consists of "must dos" identified mainly through the ACTD test program and includes some operational suitability items.[17] Specifically, Spiral 1 includes global air traffic management (GATM) compliance, the upgrading of processors for the integrated mission management computer (IMMC) and SAR, the replacement of other vanishing-vendor items, enhanced mission planning to reduce the planning cycle to 12 hours, open-system common data link (CDL), and a few other subsystem adds and upgrades. As of December 2000, Block 5 "must dos" identified by ACC that were not in the planned program included the ground moving target indicator (GMTI), EO/IR sensor characterization, crypto-security (periodic encryption code changes during a long mission), the ground safety camera, and see-and-avoid/detect-and-avoid equipment (camera, traffic collision avoidance system [TCAS]). However, all these items except crypto-security had been included in the plan at the time of transition to MDAP status (March 2001). One issue here is that program participants do not agree on the relative priority given to items on the "must do" list owing to differences in perspective and organizational interests.

The Block 5 to Block 10 (Spiral 2) increment includes major upgrades to the system. This step was largely unfunded until recently (FY 2001 POM). Block 10 would include a survivability suite, weather detection, electrical power improvements, sensor improvements, and other not-yet-defined improvements and enhancements. Blocks 5

[17]As noted above, the ACTD configuration itself includes Block 1 and Block 2, which incorporate improvements resulting from the ongoing NRE activities.

and 10 are product improvements initiated by the Air Force during the EMD to meet the ORD.

The first true Block 5–configured aircraft is air vehicle 8, which is designated P-1 because it is considered the first production aircraft. It will not be delivered until the third quarter of FY 2003 under the latest plan available (October 2000). Current funding supports a total of twelve Block 5–configuration aircraft. Also, the timing of the continuing activities may require retrofitting of the first air vehicles.

Table 3.1 compares the planned upgrades for the two initial spirals as they existed at the beginning of FY 2001. Spirals 3 and 4, which incorporate further upgrades as part of the spiral development approach, were in the early discussion and planning stages.

Table 3.1

Global Hawk Spiral Development Performance Upgrades

ACTD[a]	Spiral 1 (Block 5)	Spiral 2 (Block 10)
30–35 hours endurance	30–35 hours endurance	Weather hazard and detection
Missing planning takes weeks	12 hours mission planning	Survivability suite
No antijam GPS		Electrical power improvements
ACTD EO/IR/SAR	Upgraded IMMC and sensors	High-speed fueling/defueling
Partial CDL	Open system architecture CDL	Sensor improvements
No tech orders	Tech orders, training	
Limited spares and training	TCAS functionality	
	GATM	
	See and avoid (nose camera)	
	Alternate/divert base launch and recovery[b]	
	Direct downlink capability	
		Other (pending ORD and MUA)

[a]GPS = Global Positioning System.

[b]This capability is inherent in the OmniSTAR Defense GPS.

The approved SAMP dated November 2000 indicates those capabilities that were added to the ACTD configuration (see Table 3.2). However, many of the items listed are very general, and the SAMP allows the program manager to delay the incorporation of added capability if such capability would introduce "unnecessary risk."[18]

Block 10 upgrades are funded in the POM (FY 2004 start). Long-lead items for Block 10 production systems have been programmed for FY 2007, with first delivery in FY 2009. Signal intelligence (SIGINT) payloads will be funded beginning in FY 2004.

A formal system engineering process has been planned to accomplish these configuration changes and capability improvements.

Table 3.2

Added Capability Through Spiral Development

Block 5	Block 10
Open systems architecture enablers	SIGINT
Ku-band data link	Survivability suite
274-megabit-per-second common data link	Image recorder
Mission planning improvements	Communications improvements[a]
	Endurance improvements
Worldwide operations (GATM/TCAS)	In-flight engine restart
	Ground shelter safety
Initial technical orders	
Initial training course development	Improved protection of classified material
IR camera	Fault detection/fault isolation
	Integrated sensor suite upgrade/power upgrade (active electronically scanned array)
	Extreme temperatures upgrades
	Operations in chemical/biological warfare environment
	Operational suitability/effectiveness

[a]Three simultaneous voice communications, electronic key management system, and demand assigned multiple access (DAMA).

[18]SAMP, November 2000, Table 4.1 (p. 35).

MIL-HDBK-500 will be used as guidance.[19] Each configuration will have an established functional baseline. The baseline for Block 5 will be the stepping-off point for Block 10. The original OSD idea to improve the performance of each aircraft was considered impractical owing to challenges in maintaining interoperability and backward compatibility and because of operations-and-support difficulties inherent in operating multiple configurations of varying capability. Performance improvements will thus be incorporated into each spiral batch to minimize parts/spares and configuration problems.

U-2 Replacement?

Just before the completion of the ACTD, the debate regarding post-ACTD activities changed radically as Global Hawk came to be thought of as a replacement for the U-2. Prior to this time, Global Hawk was thought of—and designed to be—a supplement to the U-2.[20] In the workup to the Milestone II briefing, then planned for mid-October 2000, a decision was made to revise the plan again and proceed with something called Option 2C.

This plan accelerated Global Hawk sensor capability to parity with the U-2. Block 10 systems would be delivered in FY 2006 or FY 2007 rather than FY 2009. To get there, system configurations would proceed through Block 5, Block 6, and Block 7, each of which consisted mainly of sensor upgrades that were to be implemented as they became available.[21] Eventually, all systems would be retrofit to the Block 10 configuration.

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[19]Use of this military handbook points to a significant difference from the ACTD program, in which few formal guidelines were used to help manage the process. In particular, there was no system engineering process early in the program.

[20]In program reviews during the summer of 2000, ASC Commander in Chief (ASC/CC) General John Jumper decided that a Block 10 Global Hawk was desirable earlier than initially expected as a replacement for the U-2. However, the decision made was to go through the Block 5 configuration in a spiral development approach. Interestingly, General Jumper had personal experience with the Predator UAV program and was impressed by the capabilities of this type of system.

[21]According to a personal communication with GHSPO and SAF/AQIJ personnel, the plan as of December 2000 included Block 6 and Block 7 spirals as incremental improvements that would be fielded (two air vehicles each) on the way to an ORD-compliant Block 10.

The exact details of each block remained undefined. The previous plan had a $396 million shortfall in the baseline program. There was an approximate $1 billion shortfall for Option 2C over the FYDP funding period. The mid-October 2000 DAB II was delayed as a result of a lack of firm commitment for full funding. The Under Secretary of Defense for Acquisition, Technology, and Logistics (USD)[AT&L]) decided to delay the DAB to no later than December 1, 2000. This was to provide time for the program to obtain the needed funding commitment and to revise program documentation to reflect Option 2C. At the same time, the USD(AT&L) gave approval for some EMD tasks to commence prior to the formal DAB, thus minimizing delays and perturbation in the program. In December 2000, the then–Deputy Secretary of Defense (SECDEF) declined to dedicate the nearly $1 billion over six years that was required to make Option 2C a reality.

The Milestone II date continued to slip as agreement on capabilities and funding failed to be reached. New questions about the program's future arose when the new administration entered the White House in January 2001. The new president's suggestion of "skipping a generation of weapons" put the continuation of the program in question. Milestone II, which followed the baseline program that included Spiral 1 and 2 development and production of two aircraft per year, was finally declared on March 6, 2001. Yet despite this milestone, the future of the program remains very much in flux. In the next few years, it could be accelerated to create a U-2-type capability as envisioned in Option 2C, or it could be canceled to make way for a stealthy UAV U-2 replacement.

High-level interest in the program's content (e.g., from the Secretary of the Air Force [SecAF], the Chief of Staff of the Air Force [CSAF], and the ASC Commander in Chief [ACC/CC]), specifically regarding accelerating development, was unexpected. Under Option 2C, the question was no longer how to smoothly transition Global Hawk into an acquisition program and the force structure. Now the question was how fast Global Hawk could replace the U-2. The answers to these two questions can be radically different across a number of important dimensions, including technical risk, system performance, cost, and operational suitability (technical orders, training). As a replacement for the U-2, Global Hawk is no longer an additive program within the Air Force's intelligence, surveillance, and reconnaissance

(ISR) program. It could now draw on U-2 manpower and other resources. The U-2 replacement idea was driven in part by an unwillingness to fund and maintain two force structures for essentially the same mission. The affordability of any additive program is always an issue.

The idea to replace the U-2 created significant developmental and programmatic concerns. Even in its Block 10 configuration Global Hawk is not a replacement for the U-2; it is more capable in some areas (endurance, geolocation) and less capable in others (sensor range, SIGINT). At the time Option 2C was in favor, the complete Global Hawk ISS (SAR and EO/IR) had not been fully characterized. Realistic comparisons to the demonstrated and predicted future capabilities of the U-2 cannot be made, as Global Hawk has no SIGINT capabilities. Further, the nature of the two systems is significantly different, resulting in very different CONOPS. In the end, this difference boils down to the simple fact that Global Hawk is an autonomous UAV with a payload capacity of about 2000 pounds while the U-2 is a manned aircraft with a payload capacity in excess of 4000 pounds.

The MUA and the Plan

The program office had viewed the then-planned September 27, 2000, DAB II decision point as the end of the ACTD. However, the Milestone II decision subsequently slipped first from September 27 to October 16, 2000, then to December 2000, and then to March 2001. This series of schedule slips reflected continuing disagreement regarding elements of the future acquisition approach. However, the MUA was formally released in September 2000, essentially marking the end of the ACTD program.

The results of the MUA were highly supportive of Global Hawk.[22] The MUA states that Global Hawk "successfully demonstrated military utility . . . [and] demonstrated [that] a 32+ hour endurance platform, interoperable with intelligence exploitation systems from all

[22]U.S. Joint Forces Command, *Global Hawk System ACTD Military Utility Assessment*, April 1995 to June 2000. DarkStar never entered a D&E phase, so the MUA was limited to Global Hawk, not the HAE UAV ACTD program.

services and a North Atlantic Treaty Organization partner, can positively influence the outcome of military operations." The final MUA report describes the assessment methodology in some detail but notes in particular that the Joint Operational Concept document developed by JFCOM formed the basis of the D&E phase and is the starting point for "continued concept refinement/expansion." The document includes selected detailed demonstrated accomplishments supporting the three MUA objectives of effectiveness, suitability, and interoperability. The three operational challenges identified in the MUA include mission planning (where improvements were said to be needed), communications (where robustness and DAMA compliance are needed), and transition (where continued use of residual assets in D&E was recommended). Among the recommendations of the MUA are as follows:

- Declare a Milestone II decision initiating EMD and approve LRIP.
- Use spiral development to quickly field an operationalized version and upgrade capabilities over time.
- Emphasize mission planning improvements.
- Establish a multiservice and joint exploitation architecture.
- Provide robust worldwide SATCOM availability and accessibility for command and control and imagery dissemination.
- Aggressively coordinate efforts with the FAA to expand UAV operations.

The overall tone of the report, as well as its specifics, indicates that JFCOM was satisfied with the capability represented by Global Hawk. It is notable that Global Hawk is treated as a supplement to existing ISR assets, not as the U-2 replacement that it is fast becoming.

The ORD developed by AC2ISRC, was still in draft form at the end of September 2000.[23] AC2ISRC was also developing a SIGINT annex to the ORD to guide the development of Block 10 SIGINT capabilities.

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[23]See AC2ISRC, *Basic Systems for the Global Hawk Unmanned Aerial Vehicle (UAV) System*, Operational Requirements Document CAF-353-92-I/II-C, September 25, 2000.

In November 2000, the GHSPO published an approved SAMP for the post-ACTD effort. This SAMP included much of the detail that had been left incomplete in the earlier draft version. Nevertheless, since the program had yet to pass a Milestone II decision, there remained considerable ambiguity in the future program. The November 2000 SAMP did provide the following information defining the outline of post-ACTD activities:

- Ryan was given TSPR. Raytheon became a subcontractor responsible for the ground segment.
- Contracts for EMD, LRIP, and logistics support will be established according to the FAR. OTA will no longer be used.
- A spiral development approach will be used, with at least a Block 5 and a Block 10. Block 10 will be ORD compliant. Spiral development will commence in FY 2001. The development of Block 10 will include active electronically scanned array (AESA) technology. SIGINT capabilities will begin with Block 10.

The baseline program is presented in Figure 3.2.[24] According to the SAMP, this program would include a total of 12 Block 5 imaging intelligence (IMINT)-only aircraft beginning in FY 2002 at a rate of two per year through FY 2007. Two CGSs would also be procured. Full-rate production would begin with the FY 2005 purchase. A Block 10 aircraft with both IMINT and SIGINT capability would be procured at a rate of four per year beginning in FY 2008 (long lead in FY 2007), with the first delivery in FY 2009. Twenty-five Block 10 IMINT and 26 SIGINT air vehicles would be procured. Total procurement would consist of 63 air vehicles and 14 CGSs through FY 2020.

Figure 3.2 indicates that Spiral 1 (Block 5) would take three years to achieve (FY 2001–2003) and that Spiral 2 (Block 10) would take four years (FY 2004–2007). Such time lines appear inconsistent with the short (i.e., one-year) development effort that had previously been discussed. The large pre-EMD appears to be required to provide the Block 5 capability.

[24]From GHSPO (ASC/RAV), "Global Hawk System Program Overview," briefing, December 14, 2000.

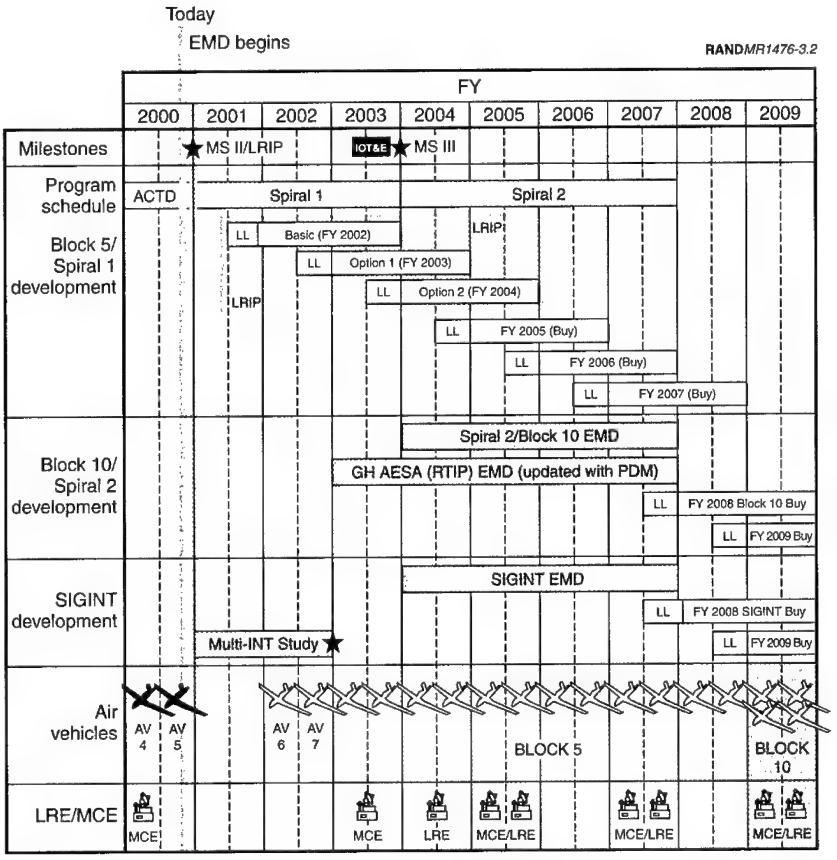

Figure 3.2—Global Hawk Baseline Program Circa December 2000

The November 2000 SAMP also updates program risks:

- **Technical/interface:** SIGINT ORD requirements in draft stage will affect the ORD, test and evaluation master plan (TEMP), schedules, cost estimates, etc.
- **Cost/funding:** The SIGINT, Radar Technology Improvement Program (RTIP), and AESA new-sensor development efforts introduce greater levels of risk than legacy systems. Additionally, these programs are not baselined, so costs are not fully known.

- **Schedule:** An aggressive EMD/LRIP schedule with multiple overlapping spiral development efforts and related sensor development programs affect Global Hawk.
- **Program:** Contingency operations could affect the ability to execute the program; in addition, the interdependent development of various sensors increases integration requirements, which in turn increases risk.
- **Sustainment:** Neither life-cycle management nor a maintenance concept has yet been defined.

The SAMP indicates that the overall program risk is moderate.

While adding considerable detail to the outline of the post-ACTD program, the November 2000 SAMP was still incomplete or inaccurate in some respects. The SAMP was approved, but a program was not completely and unambiguously defined and approved. The SAMP did include a provision for annual review and updating as necessary.

Program documents from November and December 2000 indicate continued flux in the program plan for post-ACTD activities. Funding was perhaps the dominant issue. Funding shortfalls in the future program make the program unexecutable. Additional options that reduce required Air Force investment within the FYDP (e.g., a slower buildup to full-rate production or the deferral of some Block 10 requirements) were developed. In mid-December, funding decisions were deferred by the Deputy SECDEF, resulting in a further slip of Milestone II and in preparatory meetings by the OIPT with no rescheduling. The aggressive EMD schedule of the baseline program was noted as a moderate risk.

Despite this ambiguity, NRE activities, planning for the Australian deployment and demonstration, and early planning for mission expansion and associated payload upgrades (mostly through participation in meetings with interested parties) continued.

Post-ACTD Contracting Approach

In weapon system acquisition programs, the transition from one program phase to the next is often accompanied by a change in

contracting strategy. Development contracts most often use some form of cost-reimbursable mechanism (i.e., cost plus fixed fee [CPFF], cost plus award fee [CPAF], or cost plus incentive fee [CPIF]) because technical maturity and requirements are less certain, while production contracts more often use a fixed-fee mechanism (i.e., firm fixed price [FFP]) because the product can usually be precisely specified.

The HAE UAV ACTD program used OTA as the vehicle to define the relationship between government and contractor and sometimes between contractors (e.g., Boeing and LMSW, Ryan and Raytheon). Section 845/804 OTA provides a blanket waiver of all traditional acquisition policies, procedures, and regulations. Most significantly, the use of OTA meant that the traditional milestone criteria, reporting, and oversight embodied in the DoD 5000 series of regulations, the contracting and cost accounting standards embodied in the FAR and Defense Federal Acquisition Regulations (DFAR), and the procedures embodied in military specifications and handbooks do not need to be followed. However, OTA does not provide a substitute for these established policies and practices; instead it relies on the skills of the contracting officers and program managers to structure an approach reflecting the program's objectives and characteristics. This significant degree of flexibility usually results in highly tailored program management structures as well as in a dramatic increase in contractor design and management responsibility and authority. Benefits can include significant overhead cost reductions, faster decisionmaking, and potentially more innovative design solutions tailored to the characteristics of the system and program context.

Although the entire ACTD program is technically developmental in nature, limited quantities of air vehicles and ground segments were fabricated. In an MDAP, distinctions are made between types of development (prototyping efforts, demonstration/validation, EMD) and production (LRIP and full rate) and the type of funding authorized. The original authorizing legislation for OTA limited its use to prototyping programs (which are not part of an MDAP). Legally, OTA cannot be used for production.[25] The legality of using OTA for EMD

[25]The program office (and OUSD[A&T]) asked Congress for authority to use Other Transactions (OT) in production, but this request was not granted.

was at first uncertain and had apparently not been tried. With the assistance of the ASC legal team, the program office determined that EMD could be executed as an OTA under current law.

The GHSPO presumed that the post-ACTD contracting approach would be a continuation of OTA into EMD (CPAF) and a FAR-based contract in production (fixed-price incentive fee [FPIF] or fixed-price award fee [FPAF]). The program office argued that the continuation of OTA provided the following benefits:

- Relief from Cost Accounting Standards (CAS) (relying instead on contractors' internal and commercial audits;
- Relief from Truth in Negotiations Act (TINA) requirements (instead determining price reasonableness in lieu of a full cost analysis);
- Exemption from Competition in Contracting Act (CICA) compliance;
- Reduced reporting (reducing administrative burden);
- Simplified tailoring to program needs; and
- Allowance for a higher degree of responsiveness to program changes.

The alternative would be the transition to the contracting and management of all FAR-compliant systems or transitioning to these systems partially while attempting to obtain a number of waivers for those critical management processes that are not FAR compliant. In late summer 2000, however, OSD directed that EMD would be FAR-based.

The GHSPO and the contractors began to transition to FAR-compliant systems for the EMD. This increased reporting and oversight burden (or level of effort, which translates into greater cost) in both contractor and GHSPO organizations. It also entailed a cultural shift back to a more traditional approach as well as to a more adversarial relationship between government and contractor. Fortunately, the GHSPO anticipated the need for this change. Plans and activities related to changing the overall acquisition approach commenced soon after the management transition from DARPA to

the Air Force took place. The level of effort in these activities increased significantly over time.

The program office had to retain parallel OTA processes for the execution of Phase IIC, for the building of air vehicles 6 and 7, and for the relatively large pre-EMD effort put on contract earlier that summer. These efforts, which amounted to almost $200 million in work, were to stretch well into 2002. This meant that the program office would be executing parallel acquisition strategies—i.e., strategies that would be both OTA and FAR compliant—for at least two years.

The change from an Other Transactions (OT) environment to a traditional FAR-based contracting strategy, along with the management change from ACTD to MDAP status, entailed the development of all the traditional program documentation, including the following:

- An ORD;
- A system engineering master plan (SEMP);
- A TEMP;
- An acquisition decision memorandum;
- A system requirement document;
- A system performance specification;
- Monthly acquisition reports;
- A defense acquisition executive summary (DAES);
- A selected acquisition report (SAR);
- A cost performance report;
- A contract funds status report;
- A contractor cost data report;
- A program management directive;
- A command, control, communications, computers, and intelligence support plan (C4ISP) and
- A SAMP.

The program office was responsible for many of these documents; the contractor was responsible for some. Decision memoranda result from program reviews. Many of these documents did not have an HAE UAV ACTD program equivalent. Developing these documents and creating processes to maintain and update them as needed add some unknown cost to the program. However, processes implied by these documents also have some value in terms of program management and oversight. The balance is not clear, but such considerations should be part of the decision process regarding the use of OT.

Although most program observers expected the transition from an OTA environment to a FAR-based contracting environment to be difficult and costly, some program participants noted that the transition has not been as difficult as expected. Both contractors (Ryan and Raytheon) have experience with FAR-based systems; they were just not used on Global Hawk. The acquisition of Ryan by Northrop Grumman adds to Ryan's capabilities in this respect. Nevertheless, the cultural shift is likely to be difficult. At this point, most of the personnel associated with Global Hawk have been indoctrinated into the OTA approach; indeed, the OTA process has become the natural standard operating procedure for the program. However, the cost of the transition to FAR-based contracting remains to be determined. While much uncertainty exists, estimates of the cost penalty associated with the change from OTA to FAR-based range from 20 percent to 25 percent of system engineering and program management (SEPM) costs to between 20 percent and 25 percent of the entire program.

Pre-EMD Activities

A pre-EMD contract was signed prior to the end of the ACTD. This contract was intended to bridge the gap from the end of the ACTD (June 30, 2000) through the end of the fiscal year and the planned beginning of EMD. The contract uses OTA and contains development-type activity, including endurance improvements, direct downlink capability, alternate/divert-base launch and recovery, mission planning improvements, sensor and IMMC vanishing-vendor issues, and interim technical orders. These activities

represent continuations of NRE efforts that were under way earlier in the ACTD program. The main NRE activities included:

- Mission planning improvements whose goal was to eventually reduce the time from three weeks to one day for Block 5 and then to 12 hours for Block 10.
- The development of technical manuals and support procedures.
- The resolution of the IMMC vanishing-vendor problem through the purchase and integration of the next generation of processors.
- Allowing next-generation radar processors and transmitters to be incorporated.

The cost of post-ACTD development activities is a combination of OTA- and FAR-based efforts. Rough cost estimates for the one-year EMD program under discussion were approximately $30 million in NRE for a Block 5 and more than $60 million in NRE for a Block 10 configuration; both options were dependent on the $118 million pre-EMD NRE activities initiated under the ACTD program and scheduled to be completed roughly two years after completion of the ACTD.[26]

Industrial Base

The HAE UAV ACTD program has raised some challenging industrial-base issues. The issue that has received the most attention has resulted from the gap between the fabrication of the last ACTD-configured air vehicles and the fabrication of the first LRIP configuration. In the original program structure, this gap was at least two years long—much too long for Ryan to maintain its manufacturing capability. The solution to this problem, directed in the August 1999 IPDM, was to build two additional ACTD air vehicles (air vehicles 6 and 7) at the end of the ACTD program and into EMD.

[26]For a complete account of development costs, see Robert S. Leonard and Jeffrey A. Drezner, *Innovative Development: Global Hawk and DarkStar in the HAE UAV ACTD—Program Description and Comparative Analysis*, MR-1474-AF, Santa Monica: RAND, 2001.

This gap filler did not completely solve the problem. Both Ryan and Raytheon had to reduce their program staffing by about 50 percent as the ACTD drew to a close. This was due to the lack of funding that was to be provided by the post-ACTD program in the near future. Many personnel were moved to other programs, and it is not clear that they will be available for Global Hawk should the effort build up. This raises an issue of workforce continuity (and thus experience) that was not completely resolved by the pre-EMD and small Spiral 1 EMD contracts. An earlier decision (a preliminary assessment and a decision to program funds) on the future program during the ACTD might help alleviate this problem.

An additional issue was Boeing's refusal to build additional wings for Global Hawk; Boeing determined that such work was not cost-effective and could not be made profitable at the low production rates contemplated for the future program. A wing for Global Hawk takes about 18 months to manufacture. Ryan released a request for proposal (RFP) to find another subcontractor, but five potential subcontractors responded that they were not interested. One respondent indicated that it would fabricate the wings, but at a cost of $11 million for one set or $11 million for three sets. The implication here is that nonrecurring cost is the driver for wing fabrication. This issue was resolved only after Northrop Grumman purchased Ryan and decided to produce the wing in house.

The purchase of Ryan by Northrop Grumman appears to have greatly facilitated the transition to MDAP status. Ryan was a prime for small drone contracts and a subcontractor for larger programs. It did not have the administrative infrastructure to execute an MDAP as a prime. Ryan also lacked political savvy and did not have the political access necessary for the successful execution of a multibillion-dollar program. The "big program" expertise of Northrop came at just the right time for the program's transition into spiral development. Ryan would have had difficulty on its own, and all parties were better off with Northrop Grumman. However, Northrop Grumman's expertise came at a price of increased overhead costs.

Summary of Global Hawk Post-ACTD Planning

There is a sense among some program participants that the currently planned program is moving too fast. There is also a strong sense that

operational experience should be gained with the Block 5 configuration before the systems are upgraded or payloads added. A focus on new payloads too soon could interfere with the EMD involving the initial payloads.

The ACTD experience provided a sound basis for identifying a highly tailored EMD that includes only those activities necessary to field an operational and supportable system. ACTD accomplishments subtly influenced post-ACTD planning and potential activities through stakeholder discussions. Continuous interaction between JFCOM, the GHSPO, the 31st TES, ACC, and others provided opportunities for real-time input into the formulation of post-ACTD plans. The planning function was not (and should not be) deterministic (i.e., a point decision node). Thus, the three-part EMD for Global Hawk (pre-EMD, Spiral 1, and Spiral 2) could be a much lower risk and hence a less costly phase than in many traditional programs. However, many of the traditional factors affecting MDAP outcomes have influenced Global Hawk. Requirements creep and funding shortfalls perhaps had the greatest impact, resulting in a program with significant risk if a U-2-type capability is ultimately sought.

Chapter Four

CONCLUSIONS

Critics of the ACTD construct, particularly in Congress, note that ACTDs provide a mechanism for initiating system development without all the normal approvals usually applied to MDAPs. Critics of OTA use believe that government interests are not adequately protected under the more relaxed management processes inherent in OTA implementation, maintaining that such processes bypass many of the traditional checks and balances of the acquisition process. Additionally, if an ACTD were not a formal acquisition program but would eventually transition into one, questions remain regarding how issues of funding, requirements, and integration into operational use should be addressed. These issues persist seven years after the beginning of the HAE UAV ACTD. Two issues in particular have yet to be resolved: the relationship of an ACTD program to the traditional acquisition process, and the affordability and integration of Global Hawk into the force structure within the context of an existing U-2 force with known capabilities.

IMPACT OF THE HAE UAV ACTD'S INNOVATIVE ACQUISITION STRATEGY

For the most part, we believe that the transition of management responsibility from DARPA to the Air Force within the ACTD program was not significantly affected by the innovative acquisition strategy used in the HAE UAV ACTD program. In fact, the program plan both called for and made provision for that management change. DARPA management was the only way to initiate the program using OTA: The 1994 public law provided OTA solely to defense agencies. Some

three years later, the law was extended to the military services, allowing management under OTA to continue when the program transitioned to the AF.

Several elements of the innovative acquisition approach used during the ACTD program directly affected both the transition to the formal acquisition process and the introduction of Global Hawk into the operational forces. In particular, several elements of this strategy resulted in substantial challenges for the transition to an MDAP: designation as an ACTD, use of OTA, early user involvement, and the lack of performance requirements.

Designation as an ACTD

A 1999 U.S. General Accounting Office (GAO) report suggests that the ACTD concept was still not well understood as late as 1998. This ambiguity was said to stem from confusion regarding whether an ACTD is a technology development effort or a system development program.[1] Related issues include the use of mature technology (which might still have a significant integration challenge), the need to demonstrate operational characteristics, and the lack of production or suitability testing. This GAO report lends support to the notion that the ACTD concept is plagued by internal conflicts—conflicts that clearly affected the HAE UAV ACTD program, particularly in terms of the transition to an MDAP.

The ACTD designation constrained MDAP transition planning until very late in the process and created a challenging budgeting problem for the future. In addition, the roles of the ACTD and MDAP users were ambiguous and even conflicting, thereby contributing to tension and uncertainty with regard to future performance and CONOPS.

Any transition from development to production requires that production funds be budgeted at least two years ahead of time (a single PPBS cycle takes two years). In longer development programs, service users have more time to gain familiarity with the system and to

[1]See U.S. General Accounting Office, "Defense Acquisition: Advanced Concept Technology Demonstration Program Can Be Improved," GAO/NSIAD-99-4, October 1998.

become comfortable with its characteristics and expected capabilities. In the current case, the HAE UAV's ACTD status placed it outside the normal POM/PPBS process guiding production funding. Budgeting problems were complicated by the fact that the Air Force did not decide to pursue Global Hawk until around January 1999, when it canceled DarkStar in order to focus resources on Global Hawk. At that time, funding for the program was added to the Air Force FY 2000 POM. Program funding prior to that time had derived first from DARO and DARPA and later from DARPA and from funds transferred to the Air Force from DARO when the latter was stood down.

While an ACTD is not formally an acquisition program, in this instance it is a new approach to the design, development, and test of representative systems. Although an ACTD concludes in a military utility decision by the designated user, there has not been a corresponding change in the requirements and funding processes. The POM process requires inputs two years before the military utility decision marking ACTD completion. Placing a budget wedge in the POM requires convincing Congress; the wedge may disappear if the program is terminated, becoming unavailable for reallocation within the lead service. This is potentially a high budget risk, particularly if the ACTD program would eventually lead to the replacement of an existing program and thus directly compete for resources. This issue is compounded if the ACTD did not originate in the military service. Both of these constraints apply in the case of Global Hawk. The ACTD designation was a significant factor underlying much of the difficulty encountered in defining a post-ACTD program.

The ACTD program resulted in a Global Hawk system of significant maturity (and allowed the cancellation of the more immature DarkStar). This could lead to significant cost and schedule savings in EMD relative to a more traditional approach; post-ACTD activities can be highly tailored to build on what has already been achieved, including a modified development test/operational test (DT/OT) program. Obtaining those benefits requires that the user community (both product users and operators) agree that the baseline ACTD configuration has military utility and provides a strong foundation for subsequent improvements in capabilities. By its very definition and nature, an ACTD is not a development program leading to the direct replacement of an existing capability and should not be

treated as such. This continues to be a major problem for Global Hawk. Although an ACTD program has an important role in demonstrating new technologies or operational concepts, for complex systems such as Global Hawk there should be no expectation of transitioning directly to production; some additional development will be required and should be planned from the outset.

One possible reason the implications of the ACTD designation have been so troubling for Global Hawk pivots on the uniqueness of the HAE UAV program as an ACTD. The expected total cost of the HAE UAV program accounted for 37 percent of the total expected cost of the ACTDs initiated in FY 1995. The HAE UAV program accounted for 18.7 percent of the total expected cost of the 46 ACTDs initiated through FY 1998.[2] The HAE UAV program is clearly much larger than most ACTDs; of the 46 such programs initiated through FY 1998, only five had expected total costs greater than $200 million. Additionally, the HAE UAV ACTD program in general and Global Hawk in particular appear very close to the type of complex system development normally undertaken in the traditional acquisition process. A review of 16 completed ACTDs initiated through FY 1997 indicates that most of the efforts resulted either in a useful residual capability that satisfied the need (no additional production was required) or in the transfer of ideas or technology into emerging weapon system concepts. Finally, the bias inherent in ACTD guidance toward LRIP as the transition point—reflected in the way the HAE UAV ACTD was executed—implies that little thought is given to post-ACTD development activities that might be either needed or desired by the actual operational user in order to make the system acceptable.

This leads to an important issue that we offer for consideration. Given the tremendous challenges of transitioning an ACTD to a traditional acquisition process with entry at EMD, we must ask whether the benefits of an ACTD are really associated with the specific hardware/software system used to demonstrate military utility or, alternatively, whether its true benefits lie in less tangible areas of technology, knowledge, and operational concepts. If the real benefit of an ACTD is knowledge-based rather than hardware-based, then it

[2]See Congressional Budget Office, "The Department of Defense's Advanced Concept Technology Demonstrations," 1998.

would be possible to obtain those benefits even if we started over with a new design competition. Some of the management lessons tied to other elements of the HAE UAV ACTD program's innovative approach could be applied to that new program.

The ACTD concept, as implemented in the HAE UAV ACTD program, had some significant flaws that reduced the transfer of benefits and experience from ACTD to post-ACTD activities. ACTD transition guidance leans strongly toward transition to LRIP, with very little in the way of lessons or suggestions for transitioning to EMD. The fact that so many items important to operational systems are neglected during the ACTD program (e.g., maintainability, reliability, training, and documentation) strongly suggests that for a complex program such as the HAE UAV ACTD, the more realistic expectation is transition to EMD. The original HAE UAV ACTD program anticipated a Phase IV production phase in which an additional ten air vehicles of each type would be procured. This may have been a useful way to define and control costs, but it was clearly an unrealistic expectation.

The evolutionary acquisition approach that is being used in Global Hawk—and that was recently embodied in the DoD 5000 series of policy documents—raises the question, To what extent is an ORD really an ORD? In traditional programs, ORDs are developed and approved prior to program initiation and remain relatively static. Requirements are stated in terms of both thresholds (must-meet criteria) and objectives (we would eventually like to be at this higher level of performance). In evolutionary acquisition, the notion is to continuously improve performance by means of ongoing NRE activities using feedback from both fielded units and the test program. In this scenario, the ORD would evolve along with the system's capabilities. Evolutionary acquisition seems better suited to an approach such as that of the system capability document (SCD), which was pioneered in the now-defunct Arsenal Ship program.[3] This approach, which provided broad outlines for the capabilities that were sought from the system, was easily changeable as the program evolved. The capabilities described in the SCD would be different for

[3]See Robert S. Leonard, Jeffrey A. Drezner, and Geoffrey Sommer, *The Arsenal Ship Acquisition Process Experience: Contrasting and Common Impressions from the Contractor Teams and Joint Program Office,* MR-1030-DARPA, Santa Monica: RAND, 1999.

the ACTD-, Spiral 1-, and Spiral 2-configured Global Hawk air vehicles. The SCD concept seems appropriate for use DoD-wide given the spiral development approach currently being embraced for weapon system development.

The HAE UAV ACTD program was clearly affected by the "not invented here" syndrome so common in the transfer of ideas, technologies, or processes between organizations. The Air Force did not conceive of or design the HAE UAV ACTD program. The innovative acquisition approach exacerbated this problem. OSD essentially forced the Air Force to accept the program. Important elements of the Air Force (ACC) were not involved until very late in the program, and even then, it was AC2ISRC—a relatively new organization within ACC that is responsible for ISR systems—that was involved with the program, not the wider operational Air Force.

Air Force acceptance of Global Hawk (and the HAE UAV in general) has been problematic; there was no mechanism in the Air Force to obtain support for the program because it fell outside the POM planning and budgeting cycle and represented a new capability and operational concept. Global Hawk had trouble gaining support in the ISR community because it was viewed as an unknown system competing against a known capability—the U-2. The joint community supported Global Hawk because it was an information-based platform that directly supports Joint Vision 2010. The acquisition community supported the program because it represented radical acquisition reform that worked. Without OSD direction, the required Air Force budget would not have been made available. Some program participants believe that without OSD direction, neither HAE UAV ACTD program would have survived.

ACTD programs often deemphasize logistics; such concerns were expressly not part of the original conception of the HAE UAV ACTD program. In some respects, an ACTD approach will always deemphasize reliability, maintainability, and supportability (RMS). RMS is best designed into a system up front because the redesign of a mature system is costly. In the case of Global Hawk, training, technical orders, and documentation for air vehicle support were limited, as were training and documentation for the ground segment. The contractors successfully supported flight testing, but their processes were not formally documented until toward the end of the ACTD.

There are no future plans to build an infrastructure to support the ACTD configuration, calling into question the Air Force's ability to utilize the program's residual assets. Logistics issues are only now being considered for Block 5 aircraft. Attaining a balance between an ACTD's focused effort to demonstrate the utility of a new technology or operational concept and the efficiencies gained by designing in supportability attributes remains a difficult challenge, and one that must be properly addressed within the context of each individual ACTD program.

Use of OTA

The transition from the management processes and cultural norms developed under the flexible OTA mechanism back to traditional FAR-based processes was expected to pose a major challenge. Yet while the challenge was considerable, the transition went remarkably smoothly, in part because the program office planned for it and in part because Northrop Grumman's expertise in FAR-based management was brought to Ryan through its acquisition by the larger firm. We note, however, that both the contractors and the program office spent significant time and energy transitioning back to FAR-based processes. As a result, substantial non-value-added costs were likely incurred, although the magnitude of such costs cannot easily be measured. The program office is currently in the position of executing side-by-side EMD efforts under OTA- and FAR-compliant processes. Its willingness to accommodate both processes rather than simply shifting all EMD activity to FAR compliance proves the significant advantages gained from operating under the permissive and flexible OTA construct.

Early User Involvement

The ACTD construct also includes early user participation. A critical issue in this context concerns defining who the user is and thus who has the responsibility and authority to determine system specifications and to judge military utility. In most programs, system specifications are a direct result of the performance thresholds stated in the ORD; the ORD is developed by the operational user (in this case ACC). In the HAE UAV ACTD program, no ORD was developed during the ACTD program, and a commander in chief, or CINC (JFCOM),

was the designated user. The differing perspectives of these two users result in very different criteria for evaluating the military utility of the system. Both criteria have validity, and both should thus be considered in determining military utility.

Further, the ACTD process itself introduces a different way of determining military utility. In an ACTD, utility is judged against demonstrated capabilities through use of basic criteria established earlier in the program. Those criteria may not incorporate all aspects of operational utility. In a traditional program, an ORD is developed against a mission need with detailed system specifications relating to specific performance attributes. The system is then designed to those specifications, and if the stated performance is demonstrated, utility is presumed. This process is conducted in the absence of information regarding technological feasibility, risk, and cost. Neither process can be considered "correct"; both have significant problems in execution and will produce different performance outcomes. However, the ACTD process—modified to include both the unified command (in this case JFCOM) and the force provider (in this case ACC) in the design and execution of D&E activity—has the potential to produce a better and more balanced performance outcome as well as to smooth the transition to an MDAP. At the same time, there is a risk that including the force provider early in the ACTD will diminish the innovation desired from the ACTD program.

Performance specification issues illustrate a critical challenge in the transition from an ACTD to an MDAP: the user also transitions. One aspect of this problem is illustrated as follows: AC2ISRC was responsible for drafting the ORD. An early draft ORD had 105 threshold requirements. By one estimate, Global Hawk would not have met 40 percent of those requirements in the Block 5 configuration. Had this situation remained, Global Hawk would have been set up for failure. In the acquisition community, many participants felt that the ORD should have been written to reflect the demonstrated capabilities of the ACTD configuration, with subsequent planned improvements implemented through the evolutionary approach. ACC was concerned that funds would not be forthcoming in the future to accomplish evolutionary acquisition; corporate Air Force support did not exist to ensure incremental funding.

In light of the experience of the HAE UAV, the notion of early user participation in ACTDs would appear unrealistic in at least two ways. First, as discussed above, the ACTD designated user (a unified command) is not the same as the service user (operational commands). These two user communities have vastly different perspectives, roles, and capabilities. For the HAE UAV, the CINC (JFCOM) includes imagery analysts and force deployment decisionmakers; the operational user (ACC) is the force provider. For Global Hawk, the result was two differing sets of requirements suited to different CONOPS. Second, the CINC does not really have the resources and capabilities to support detailed technical interaction with the development community regarding desired capabilities and how those capabilities might be translated into performance characteristics. The service operational commands do have the resources and capabilities for this type of interaction.

Lack of Performance Requirements

A precise definition of military utility was not developed or communicated to the contractors until the publication of the integrated assessment plan in June 1998. This plan defined the MUA assessment process in detail, including the definition and metrics for military utility.[4] This was very late in the development cycle for the HAE UAV systems, and in any case, the relative importance of the various objectives and capabilities was never established. This lack of definition of military utility hindered performance trade-offs throughout the program's life cycle, since the contractors did not know how the loss (or gain) of any particular capability would be viewed.

The requirement for a Single Unit Flyaway Price (UFP) left open the entire spectrum of technical (performance) requirements for the HAE UAV system.[5] Unlike traditional programs, no requirements document was approved prior to RFP release and contract award

[4]See Drezner and Leonard, *Innovative Development: Global Hawk and DarkStar—Flight Test in the HAE UAV ACTD Program*, 2001, for a more detailed description of the MUA process.

[5]See Leonard and Drezner, *Innovative Development: Global Hawk and DarkStar in the HAE UAV ACTD—Program Description and Comparative Analysis*, 2001, for a complete discussion of the UFP requirement and its implications on the system's capabilities.

from which a system specification could be derived. A system specification forms the baseline configuration against which performance is measured in a traditional approach. Yet the system specification that was eventually developed for Global Hawk evolved largely after the system was designed.

Despite the various problems and challenges the HAE UAV ACTD program faced, one aspect that has received little attention is the fact that the program represents an important innovation in terms of capabilities, system type, and CONOPS. There is a strong belief among some in the science, technology, and acquisition community that the Air Force was initially resistant to the notion of stealth. The fundamental demonstrator programs proving and maturing LO technologies—Have Blue (which led to the F-117) and Tacit Blue (which indirectly led to the B-2)—were both DARPA programs. Despite a history of challenging transitions for such systems,[6] many of the Air Force's current ISR or "special duty" capabilities are embodied in systems whose basic technologies were developed in other organizations. These systems include the following:

- **E-3 Sentry:** A modified B-707 for airborne early warning, battle management, and command, control, and communications for tactical and air defense forces.
- **E-8 Joint Surveillance Target Attack Radar System (JSTARS):** A modified B-707 for ground surveillance, battle management, and command and control.
- **OC-135 Open Skies:** A modified C-135 reconnaissance aircraft for observation and verification flights over nations that are parties to the 1992 Open Skies Treaty.
- **RC-135 Rivet Joint:** A configured variant of the C-135 for real-time electronic signal reconnaissance.
- **RQ-1A Predator:** A medium-altitude, long-range reconnaissance UAV with multiple imagery sensors.

[6]For a history of technology transition challenges in DARPA, see Defense Advanced Research Projects Agency, *DARPA Technology Transition*, 1998, and Reed, Van Atta, and Deitchman, *DARPA Technical Accomplishments: An Historical Review of Selected DARPA Projects*, February 1990.

- **U-2 Dragon Lady:** An HAE reconnaissance aircraft carrying a wide variety of sensors and cameras.
- **WC-130:** A configured variant of the C-130 for weather reconnaissance.
- **E-9A:** A version of the de Havilland Dash 8 for over-the-horizon data gathering for missile tests.
- **EC-18B and D:** A modified Boeing 707 for telemetry and other data gathering to support the testing of aircraft, spacecraft, and missiles.
- **EC-130E Airborne Battlefield Command and Control Center (ABCCC) and EC-130J Commando Solo:** Modified C-130s for battlefield command, electronic warfare, and electronic combat.
- **EC-130H Compass Call:** Modified C-130s for electronic warfare/combat.
- **EC-135A/G/L and EC-135E Advanced Range Instrumentation Aircraft (ARIA):** Modified KC-135s for continuous airborne alert supporting national command and control. The ARIA version is used for telemetry data recording and voice relay.

The Predator was an earlier ACTD developed to fill the Medium-Altitude Endurance (MAE) UAV mission need. The U-2 was initially conceived and developed within the intelligence community. Of this list, two are ACTDs, several are commercial aircraft with equipment installed (B-707s or Dash 8), and several are modified C-130s or KC-135s. Mainstream service acquisition and operational communities have great difficulty adopting radical innovations, which is one of the reasons many of these innovations are developed and operated by special units.

Programs established outside the mainstream can greatly contribute to future service capabilities, and ACTD programs can be an important source of innovation, both technological and operational. The challenges Global Hawk faced in its transition reflect in part the difficulty any new technology faces upon its initial incorporation into a large institution.

Other Attributes of the Acquisition Strategy Affecting the Transitions

The use of IPPD/IPT processes appears to have had little effect on either transition. If anything, the collaborative relationship that developed between the contractor and the program office may have helped smooth those transitions.

The original DARPA HAE UAV JPO was in fact fairly small, consisting of a core of DARPA personnel supported by Air Force personnel from ASC/RAV and technical support contractors. At the time of the management transition, the Air Force program office was somewhat smaller than the DARPA JPO but subsequently grew considerably. The GHSPO (ASC/RAV) currently includes 78 Air Force personnel and technical support contractors—more than double the original size of the DARPA JPO but considerably smaller than that of most traditional programs. While this was a significant increase from prior years, some increase was clearly required. Planning for and conducting the Phase III D&E and the transition to MDAP status were new program office activities.

KEY ELEMENTS FOR SUCCESSFUL TRANSITIONS

The two different transitions that the HAE UAV ACTD program underwent present an interesting contrast. The transition of management responsibility from DARPA to the Air Force during the ACTD was remarkably smooth, especially given the poor historical experience in interagency program transfers. In contrast, the transition from ACTD to the formal acquisition process within the Air Force has been problematic despite the service's long history of successfully developing complex systems.

One explanation for this contrast is that the management transition from DARPA to the Air Force included many of the key elements required for a successful transition, while that from ACTD to MDAP violated many of these tenets. For example:

- **Early Planning:** The transition from DARPA to the Air Force was facilitated by early transition planning, which included both the DARPA and ASC/RAV program offices. Issues were raised and actions taken to resolve identified risks. In contrast, planning for

the transition from ACTD to MDAP began very late in the program—too late to resolve many of the critical issues that later became stumbling blocks (requirements and capabilities; funding and affordability).

- **Expectations and Formality:** The management transition from DARPA to the Air Force during the ACTD was planned from the outset. The transition was formally tied to a specific event, and criteria were defined to indicate the completion of that event. The ultimate decision was made by officials above the program office. In contrast, there was no agreed-upon expectation on the part of the Air Force that the program would transition into the formal acquisition process and, if it did, at what point. Further, there was no guidance and little experience to help smooth the entry of Global Hawk into the acquisition process. Nor was there any guidance or documentation on how to prioritize and resolve issues.
- **Sustained Top-Level Support from Participating Agencies:** DARPA maintained top-level support throughout the program, while Air Force support was nowhere near as strong. Within the Air Force, senior acquisition officials were more familiar with—and more supportive of—the program than were operational commanders.
- **Early Participation of Affected Organizations:** While ASC/RAV participated early in the program and supported the transfer of management responsibilities, ACC did not in fact support the transition of the program into the force structure. The HAE UAV ACTD program ran into trouble in the transition from ACTD status to the formal acquisition process in part because key elements of the Air Force—the operational user (ACC)—were not involved throughout the ACTD program. Had ACC been involved earlier, the performance of the resulting ACTD configuration might have been improved in key areas of concern to ACC (e.g., supportability), and the capabilities of the system might have been more familiar and therefore more acceptable.
- **Continuity:** The transition from DARPA to the Air Force occurred during the ACTD process at the beginning of a fiscal year. For the most part, funding issues and activity content (Phase II development testing and Phase III D&E testing) were already

agreed upon. The Air Force knew that it was responsible for funding Phase III D&E and thus programmed that money before the actual transfer of management authority.[7] In contrast, an ACTD cannot enter into the acquisition process until the MUA is completed. Thus, a built-in gap of two years results from the POM budget cycle.

A key ingredient to improving the acquisition strategy applied to the HAE UAV ACTD program is to address these transition elements much earlier in the ACTD.

Most program participants agreed that post-ACTD planning cannot wait for the MUA decision to decide the next steps. In this sense, the original plan of the HAE UAV ACTD was not realistic. The POM process effectively adds two years to the planning cycle. Additionally, there are likely to be industry-base issues in any ACTD-to-MDAP transition, as was the case in Global Hawk.[8] Transitioning thus requires the injection of post-ACTD planning into the ACTD program.

A mid-ACTD program review in which many of the decisions regarding a future program are made would seem likely to help smooth program transitions. Many of the basic outlines of a future program could be determined just after flight test begins, allowing for more time both to align the expectations of current and future program participants and to plan for future transitions in management responsibility, program phase, and technical and operational maturity.

Perhaps the most important improvement to the acquisition approach would involve the establishment of a process to ensure that the expectations of the various organizations involved in the program are aligned. In particular, expectations regarding the possible entry point of the system into the acquisition process should be thoroughly vetted. We observe that DARPA, JFCOM, and the Air Force and OSD acquisition communities were strongly biased toward entering the

[7]Funding for Phase III of the ACTD was transferred to the Air Force from DARO when the latter was stood down.

[8]Industry-base issues are commonly defined as those concerning funding gaps that would lead to a discontinuation of either development or production activities, with an associated risk of losing experienced personnel. These issues apply at both the prime and subcontractor levels.

acquisition process at LRIP with only minor modifications to the system. Current ACTD guidance on transitions supports this bias. However, the bias is unwarranted. Given both the technical and operational characteristics of the HAE UAV system, it should have been clear from the start that any transition would require further and perhaps significant development; the program was too much like a traditional service program, and the system's mission area was too close to an existing system. The acquisition community should recognize that an important result of this type of approach might be the transfer of knowledge—new operational concepts, ideas, technologies. The user community should recognize that not all systems developed elsewhere are inherently bad.

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Over the past three decades, a number of attempts have been made to develop unmanned aerial vehicles, but many of these efforts have met with suboptimal results. Recently, however, the Defense Advanced Research Projects Agency (DARPA), in conjunction with the Defense Airborne Reconnaissance Office, launched an effort—designated the High-Altitude Endurance Unmanned Aerial Vehicle Advanced Concept Technology Demonstration (HAE UAV ACTD) program—whose objective was to overcome past constraints in UAV development through the use of a new acquisition strategy. This book assesses two transitions of the HAE UAV ACTD program—the first from DARPA to Air Force management and the second from an ACTD to a Major Defense Acquisition Program (MDAP)—toward the goal of determining which elements of the program's novel acquisition strategy facilitated these transitions and which engendered problems. The authors found that in aggregate, the innovative acquisition strategy adopted in the HAE UAV ACTD program had a positive effect on program execution in that it successfully attained the program's key goals: demonstrating a new operational concept at a lower cost and in a shorter time frame than would have been possible with a traditional acquisition approach. The program's transition from the ACTD construct to an MDAP, however—although ultimately successful—posed a number of challenges, many of which stemmed directly from its acquisition strategy. To circumvent these problems in the future, the authors recommend modifications to the strategy.

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